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VOL. XIX.

CRAG FORAMINIFERA.

PART I.

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SUPPLEMENT

TO THE

FOSSIL CORALS.

PART I.

(TERTIARY.)

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FOSSIL MEROSTOMATA.

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VOLUME XIX.

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SHOWING THE DATES OF THE SEVERAL MONOGRAPHS,
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„ XVIII. „	1864	<ul style="list-style-type: none"> { The Fossil Echinodermata, Vol. II, Part II (Liassic Ophiuroidea), by Dr. Wright, 6 plates. { The Trilobites of the Silurian, Devonian, &c., Formations, Part III, by Mr. J. W. Salter, 11 plates. { The Belemnitidæ, Part II, Liassic Belemnites, by Prof. Phillips, 7 plates. { The Pleistocene Mammalia, Part I, Introduction, Felis Spelæa, by Messrs. W. Boyd Dawkins and W. A. Sanford, 5 plates. { Title-pages, &c., to the Reptilia of the London Clay, Cretaceous, and Wealden Formations.
„ XIX. „	1865	<ul style="list-style-type: none"> { The Crag Foraminifera, Part I, No. 1, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, 4 plates. { Supplement to the Fossil Corals, Part I, Tertiary, by Dr. Duncan, 10 plates. { The Fossil Merostomata, Part I, Pterygotus, by Mr. H. Woodward, 9 plates. { The Fossil Brachiopoda, Part VII, No. 1, Silurian, by Mr. Davidson, 12 plates.

LIST OF MONOGRAPHS

Completed, in Preparation, and in course of Publication.

MONOGRAPHS which have been COMPLETED :—

- The Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne-Edwards and J. Haime.
The Tertiary Echinodermata, by Professor Forbes.
The Fossil Cirripedes, by Mr. C. Darwin.
The Tertiary Entomostraca, by Prof. T. Rupert Jones.
The Cretaceous Entomostraca, by Prof. T. Rupert Jones.
The Fossil Estheriæ, by Prof. T. Rupert Jones.
The Polyzoa of the Crag, by Mr. G. Busk.
The Tertiary, Cretaceous, Oolitic, Liassic, Permian, Carboniferous, and Devonian Brachiopoda, by Mr. T. Davidson.
The Mollusca of the Crag, by Mr. S. V. Wood.
The Great Oolite Mollusca, by Professor Morris and Mr. J. Lycett.
The Cretaceous (Upper) Cephalopoda, by Mr. D. Sharpe.
The Fossils of the Permian Formation, by Professor King.
The Reptilia of the London Clay (and of the Bracklesham and other Tertiary Beds), by Professors Owen and Bell.
The Reptilia of the Cretaceous, Wealden, and Purbeck Formations, by Professor Owen.
-

MONOGRAPHS which are in course of PREPARATION :*—

- The Flora of the Carboniferous Formation, by Mr. E. W. Binney.
The Cretaceous Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.
The Foraminifera of the Lias, by Mr. H. B. Brady.
The Graptolites, by Professor Wyville Thomson.
The Crinoidea, by Professor Wyville Thomson.
The Jurassic, Purbeck, and Wealden Entomostraca, by Messrs. T. Rupert Jones and G. S. Brady.
The Bivalve Entomostraca of the Carboniferous Formation, by Messrs. T. Rupert Jones and J. W. Kirkby.
The Phyllopoda of the Palæozoic Rocks, by Mr. J. W. Salter.
The Polyzoa of the Chalk Formation, by Mr. G. Busk.

* Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

Monographs in course of Preparation—continued.

- The Silurian Brachiopoda, by Mr. Davidson.
The Post-Tertiary Mollusca, by Mr. J. Gwyn Jeffreys.
The Cretaceous Mollusca (exclusive of the Brachiopoda), by the Rev. T. Wiltshire.
The Purbeck Mollusca, by Mr. R. Etheridge.
The Ammonites of the Lias, by Dr. Wright.
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lancaster.
The Crag Cetacea, by Professor Owen.
The Inferior Oolite Mollusca, by Mr. R. Etheridge.
The Rhætic Mollusca, by Mr. R. Etheridge.
The Liassic Gasteropoda, by Mr. Ralph Tate.
-

MONOGRAPHS in course of PUBLICATION :—

- The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.
Supplement to the Fossil Corals, by Dr. Duncan.
The Echinodermata of the Oolitic and Cretaceous Formations, by Dr. Wright.
The Fossil Merostomata, by Mr. H. Woodward.
The Trilobites of the Mountain-Limestone, Devonian, and Silurian Formations, by Mr. J. W. Salter.
The Eocene Mollusca, by Messrs. F. E. Edwards and S. V. Wood.
The Belemnites, by Professor Phillips.
The Reptilia of the Liassic Formations, by Professor Owen.
The Pleistocene Mammalia, by Messrs. Boyd Dawkins and W. A. Sanford.

SUMMARY OF THE MONOGRAPHS ISSUED TO THE MEMBERS (up to DECEMBER, 1866) ; showing in the FIRST column whether each Monograph hitherto published be complete, or in the course of completion ; in the SECOND column, the yearly volumes which contain each particular Monograph (as a guide to binding the same) ; and in the FIFTH and following columns, the number of pages, plates, figures, and species described in the different Monographs.

I. SUBJECT OF MONOGRAPH.	II. Dates of the Years for which the Volume containing the Monograph was issued.	III. Dates of the Years of publication on the title-page of each part.	IV. Dates of the Years in which the Monograph was published.	V. No. of Pages of Letterpress in each Monograph.	VI. No. of Plates in each Monograph.	VII. No. of Lithographed Figures and of Woodcuts.	VIII. No. of Species described in the text.
The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, in course of completion	1865	1866	1866	78	4	211	43
Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by M.M. Milne-Edwards and J. Haine, <i>complete</i> (k)	1849, 1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, 1859, 1860, 1861, 1862, 1863, 1864, 1865, 1866	1850, 1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, 1859, 1860, 1861, 1862, 1863, 1864, 1865, 1866	1850, 1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, 1859, 1860, 1861, 1862, 1863, 1864, 1865, 1866	406	72	800	319g
Supplement to the Fossil Corals, by Dr. Duncan, in course of completion	1854	1854	1855	69	10	188	26
The Polyzoa of the Crag, by Mr. G. Busk, <i>complete</i>	1865	1866	1866	145	22	641	122
The Tertiary Echinodermata, by Prof. Forbes, <i>complete</i>	1857	1859	1859	39	4	144	44
The Oolitic Echinodermata, by Dr. Wright. Vol. I, <i>complete</i>	1852	1852	1852	474	43	724	109h
" " Vol. II, in course of completion	1855, 1856, 1857, 1858, 1861, 1864	1855, 1856, 1859, 1860, 1862, 1866	1857, 1858, 1859, 1861, 1863, 1866	154	19	218	29
The Cretaceous Echinodermata, by Dr. Wright. Vol. I, in course of completion	1862	1864	1864	64	11	192	13
The Fossil Cirripedes, by Mr. C. Darwin, <i>complete</i>	1851, 1854, 1855a	1851, 1854*	1851, 1855, 1861	137	7	320	54
The Fossil Merostomata, by Mr. H. Woodward, in course of completion	1865	1866	1866	44	9	50	1
The Tertiary Entomostraca, by Prof. Rupert Jones, <i>complete</i>	1855	1856	1857	74	6	233	56
The Cretaceous Entomostraca, by Prof. Rupert Jones, <i>complete</i>	1849	1849	1850	41	7	176	27
The Fossil Estheriæ, by Prof. Rupert Jones, <i>complete</i>	1860	1862	1863	139	5	158	19i
The Trilobites of the Mountain-limestone, Devonian, Silurian, and other Formations, by Mr. J. W. Salter, in course of completion	1862, 1863, 1864	1864, 1865, 1866	1864, 1865, 1866	176	25	606	95
The Malacostracous Crustacea (comprising those of the London Clay, Gault, and Greensands), by Prof. T. Bell, in course of completion	1856, 1860	1857, 1862	1858, 1863	88	22	215	50
Fossil Brachiopoda, Vol. I. The Tertiary, Cretaceous, Oolitic, and Liassic Brachiopoda, by Mr. T. Davidson, <i>complete</i>	1850, 1852, 1853, 1854	1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, 1859, 1860, 1861, 1862, 1863	1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, 1859, 1861, 1861, 1863	409	42	1855	160
" " Vol. II. The Permian and Carboniferous Brachiopoda, <i>complete</i>	1856d, 1857, 1858, 1859, 1860	1857, 1858, 1860, 1861, 1863	1857, 1858, 1859, 1861, 1861, 1863	331	59	1909	157
" " Vol. III. The Devonian and Silurian Brachiopoda, in course of completion	1862, 1863, 1865	1864, 1865, 1866	1864, 1865, 1866	219	32	1211	144
The Mollusca of the Crag, by Mr. S. V. Wood:—							
Vol. I. (Univalves), <i>complete</i>	1847, 1855b	1848	1848, 1857	216	21	581	244
Vol. II. (Bivalves), <i>complete</i>	1850, 1853, 1855, 1858c	1850, 1853, 1856, 1860, 1861	1850, 1851, 1853, 1857, 1861	344	31	691	253
The Eocene Mollusca, Cephalopoda and Univalves, by Mr. F. E. Edwards, in course of completion	1848, 1852, 1854, 1855, 1858	1849, 1852, 1854, 1860	1856, 1849, 1852, 1855, 1857, 1861	332	33	578	161
The Eocene Mollusca, Bivalves, by Mr. S. V. Wood, in course of completion	1859, 1862	1861, 1864	1861, 1864	136	20	396	146
The Great Oolite Mollusca, by Prof. Morris and Mr. J. Lycett, <i>complete</i>	1850, 1853, 1854	1850, 1853, 1854	1850, 1853, 1855	282	30	846	419
" " Supplement by Dr. Lycett, <i>complete</i>	1861	1863	1863	129	15	337	194
The Belemnites, by Prof. Phillips, in course of completion	1863, 1864	1865, 1866	1865, 1866	52	7	179	15
The Cretaceous Cephalopoda, by Mr. D. Sharpe, <i>complete</i>	1853, 1854, 1855	1853, 1854, 1856	1853, 1855, 1857	67	27	319	79
The Reptilia of the London Clay [and of the Bracklesham and other Tertiary Beds], by Prof. Owen and Bell, <i>complete</i> †	1849, 1854e	1850 *	1850, 1855	287	29	511	138
The Reptilia of the Cretaceous Formations, by Prof. Owen, <i>complete</i> †	1848, 1849, 1856f	1849, 1850 *	1849, 1850, 1859	150	58	304	39
The Reptilia of the Wealden and Purbeck Formations, by Prof. Owen, <i>complete</i> †	1851, 1857, 1858, 1862, 1851, 1859, 1860, 1861, 1864	1851, 1859, 1860, 1861, 1864	1851, 1859, 1861, 1864	184	59	519	26
The Reptilia of the Wealden and Purbeck Formations, by Prof. Owen, <i>complete</i> †	1853, 1854, 1855, 1856, 1857, 1858, 1859, 1860, 1861, 1862, 1859, 1860, 1864	1853, 1854, 1856, 1857, 1858, 1859, 1860, 1864	1853, 1854, 1856, 1857, 1858, 1859, 1861, 1864	155	62	251	17
The Reptilia of the Oolitic Formations, by Prof. Owen, in course of completion	1859, 1860	1861, 1862	1861, 1863	44	19	88	2
The Reptilia of the Liassic Formations, by Prof. Owen, in course of completion	1863	1865	1865	40	16	62	5
The Pleistocene Mammalia, by Messrs. W. Boyd Dawkins and Mr. W. A. Sanford	1864	1866	1866	70	5	43	1
TOTAL				5575	831	15,556	3207

a Index. b Title-page to Univalves. c Note to Crag Mollusca. f Supplement.
g Many of the species are described, but not figured. h British species only reckoned. (k) A Supplement is now in course of publication.
i Wants Index. m Useful for establishing the dates of new species. * Dates not given. † Marked 1857-1862.
† Title-pages and Index will be found in the 1864 Volume, or may be had separately.

THE

PALÆONTOGRAPHICAL SOCIETY.

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VOLUME FOR 1865.

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MDCCCLXVI.

A MONOGRAPH
OF THE
FORAMINIFERA OF THE CRAG.

PART I.
CONTAINING
PAGES i—vi; 1—72. APPENDICES I AND II.
PLATES I—IV.

BY
PROFESSOR T. RUPERT JONES, F.G.S.,
CORR. GEOL. INSTIT., VIENNA; ACAD. SC., PHILADELPHIA, ETC.;
W. K. PARKER, ESQ., F.R.S., Z.S., &c.;
AND H. B. BRADY, ESQ., F.L.S., G.S., &c.

LONDON:
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1866.

A MONOGRAPH

OF THE

FORAMINIFERA OF THE CRAG.

INTRODUCTION.

IN May, 1835, Mr. Edward Charlesworth read before the Geological Society of London a paper "On the Crag of part of Essex and Suffolk" ('Proceed. Geol. Soc.,' vol. ii, pp. 195-6), in which he mentioned that, "for his general information respecting the organic remains in the two beds" of the Crag, he was indebted to Mr. Searles Wood (then of Hasketon, near Woodbridge), whose collection of Crag fossils included "50 species of minute Cephalopods." These are the Foraminifera (at that time regarded generally as microscopic *Nautili*, &c.) which are brought forward in the present Monograph, to be illustrated, described, and put in comparison with other known Rhizopodal faunas, fossil as well as recent; the whole series having been liberally placed at our disposal.

Mr. Wood's original collection has been enlarged by the accumulation of specimens since 1835; but very few additional species of Foraminifera have occurred to him in his continued examination of the Crag of Sutton and elsewhere. Many of the forms met with by Mr. Wood have also been found by us in miscellaneous hand-specimens of Crag; and we have also some additional ones from these sources. We have taken about twenty forms (mostly common) from hand-specimens of Crag in which the *Cardita senilis* abounds, and nearly as many (mostly the same) from Crag with *Cyprina Islandica*; the former (*Cardita*) is very abundant at Sudbourne, as Mr. Wood informs us, and is not wanting at Ramsholt; the latter (*Cyprina*) prevails at both places in company with the *Cardita*. Some half dozen varieties we met with in a piece of Crag with *Ostrea*; but none of these are uncommon. Specimens of Polyzoan Crag have afforded thirty forms, mostly common in other varieties of the Crag. Specimens of Shelly Crag from Sudbourne, Aldborough, and Ged-

grave, have also yielded us a few Foraminifera, but, as in our other gatherings, with a paucity of individuals, and poverty of size and variety, that are strongly contrasted with the conditions under which Mr. Wood found his numerous and large specimens in the Crag of Sutton. On this subject Mr. Wood has remarked in letters to us, dated March 11th, and August 5th, 1863—"It is pretty nearly as you suspect; those fine specimens were from a special bed, which was particularly rich in those remains; and nearly the whole of what I then considered my fifty species were obtained from the Crag at one locality in the parish of Sutton. This spot, which formerly yielded to my examination specimens by hundreds (indeed, I may say by thousands), now scarcely supplies me with any. As this locality fails to furnish me with any but the commoner kinds of Shells and Foraminifera, I imagine that the rich community must have nestled in a protected nook, out of the reach of the moving waters, or in some quiet place under specially favourable conditions; and that the excavations in the deposit, as they have been extended westwards, have passed beyond this particular habitat. The bed at Sutton seems to have been a bank something like the 'Turbot-bank,' about 5 miles south of Larne (Antrim). The Crag at Sutton is somewhat isolated now, and separated from that at Ramsholt probably by denudation. At the latter place the White or Lower ('Coralline') Crag is overlain by the Red Crag; but at Sutton it has been excavated by denudation, and the Red Crag abuts against it, as has been pointed out by Lyell ('Mag. Nat. Hist.,' new ser., vol. iii, 1839, p. 314). Most of my specimens came from the east side of this hill, where the Crag deposit appears to have been sheltered; whilst on the west side the Crag is almost indurated, and its material comminuted." Mr. Wood adds that the true Polyzoan bank of the Crag (in which he found but few Foraminifera) is to be seen in the neighbourhood of Aldborough, Sudbourne, and Orford, overlying the bed wherein Shells, with occasional Actinozoa and Polyzoa, abound.

The geological relations of the several deposits of "Crag" in Norfolk, Suffolk, and Essex, have been treated of by Mr. Charlesworth in the 'Proceedings of the Geological Society,' 1835, vol. ii, p. 195, &c. ("On the Crag of part of Essex and Suffolk"); in the 'London and Edinb. Phil. Mag.' (Nos. 38 and 42, August and December, 1835), 3rd ser., vol. vii, pp. 81, 465, &c. ("Observations on the Crag-formation and its Organic Remains, &c."); and in the 'Report of the British Association' for 1836, 'Trans. Sect.,' p. 84 ("A notice of the Remains of Vertebrated Animals found in the Tertiary Beds of Norfolk and Suffolk"); also by Sir C. Lyell, 'Mag. Nat. Hist.,' 1839, new series, vol. iii, p. 313, &c. ("On the Relative Ages of the 'Tertiary Deposits, commonly called 'Crag,' in the Counties of Norfolk and Suffolk"); by Mr. S. V. Wood, jun., 'Annals Nat. Hist.,' March, 1864 ("On the Red Crag, and its relation to the Fluvio-marine Crag," &c.), also in his "Remarks in Explanation of the Map of the Upper Tertiaries of the Counties of Norfolk, Suffolk," &c., 1865; and by Mr. E. R. Lankester, 'Geol. Mag.,' 1865, vol. ii, pp. 103 & 149 ("On the Crags of Suffolk and Antwerp"). Of the three recognised divisions of the English Crag, the lowest has been known as the "Coralline

Crag" ever since Mr. Charlesworth so named it in 1835, on account of its abounding with little *coral-like* fossils, which, however, when duly studied, were found to be *Polyzoa*, Corals being exceedingly rare in it. "Polyzoan" or "Bryozoan Crag" ought, therefore, to take the place of this common misnomer; but "White Crag," "Lower Crag," and "Suffolk Crag," are still better names for this division, and are already in use. For general and special information on the Crag deposits, the reader can also refer with advantage to Lyell's 'Elements of Geology,' 6 edit., 1865, chap. xii; and to Phillips's 'Manual of Geology,' 1855, chap. xiii. In reading these, however, "Polyzoan" must be substituted for "Coralline" and "Zoophytic," with reference to the particular fossils and beds alluded to.

In 1843 Mr. S. V. Wood communicated forty-two names (some new and some after D'Orbigny) of Foraminifera found in the Crag to Mr. Morris's 'Catalogue of British Fossils.' In 1844 one of the Foraminifera of the Crag was described by Mr. Wood, in a list of the Zoophytes of that formation, published by him in the 'Mag. and Annals of Nat. Hist.,' vol. xiii, p. 21, as a sequel to the lists of the Mollusca of the Crag given by him in 1840-42 in the 'Mag. Ann. Nat. Hist.,' vols. vi and ix. These Mollusca have been fully elaborated by Mr. Wood in Monographs published by the Palæontographical Society: and the Monographs on the Cirripedia, the Echinodermata, and the Polyzoa, of the same formation, by Darwin, Forbes, and Busk, together with the account of the Corals of the Crag in the Monograph by Milne-Edwards and Haime, and of the Entomostraca in that by Rupert Jones, leave little to be done in the description of the Fossil Fauna of the Crag Formation; and the present Monograph on the Foraminifera is intended to lessen still further the remaining desiderata in that direction.

The collection of Foraminifera obtained by Mr. S. V. Wood from the Crag of Sutton comprises about eighty reputed species, or species and important varieties recorded binomially; and here we must remark that though, zoologically speaking, many of the recognised forms of Foraminifera are not *species*, but merely varieties, of different systematic values, yet, for the sake of convenience to zoologist and geologist, they have received and retain binomial appellations, that stand in the lists like specific names. The zoological value of these names is critically indicated in our papers on the "Nomenclature of Foraminifera," in the 'Annals and Magazine of Natural History' for June and November, 1859; February, March, April, June, July, and November, 1860; August and September, 1861; February, September, and December, 1863; March and July, 1865.

These Foraminifera from the Crag at Sutton are remarkable, for the most part, for size and abundance. The leading forms are *Miliola*, *Lagena*, *Nodosarina*, *Polymorphina*, *Textularia*, *Pulvinulina*, and *Nonionina*. As a fauna, they are best represented (in our collections) by dredgings from the Atlantic, south of the Scilly Isles, at from 50 to 70 fathoms, and from the Mediterranean on the north of Sicily, at 21 fathoms.

From all other parts of the Lowest or White Crag of Suffolk, as far as our collections serve, we have got a somewhat similar fauna, not only greatly reduced in number of

individuals and variety of forms, but composed of dwarfs in contrast with those of Sutton, except in the case of some of those that inhabit shallow water, as *Rotalia Beccarii* and *Polystomella crispa*, and even these are but feeble. Hence we may suppose that the Foraminiferal deposit at Sutton was formed either in deeper or in warmer water than other portions of the Crag were. Some of our sources of these less luxuriant growths are specimens of Crag full of *Cyprina* and *Cardita*; and as the former shell lives in the British seas, at from 5 to 80 fathoms—a depth similar to that affected by the Atlantic and Mediterranean groups of Foraminifera above alluded to, we must suppose that some deteriorating influence, either cold currents, floating ice, or cold climate, was at work locally, at least, in the Crag sea, excepting possibly the Sutton area.

Similar conditions are pointed out by the Bivalved Entomostraca of the Crag, the distribution of which will be treated of in an Appendix to this Monograph.

A group of Foraminifera, doubtlessly imperfect as a fauna, from a specimen of Crag with *Ostrea*, consisted of *Polymorphina Thouini*, *P. gutta*, *Textularia agglutinans*, *T. trochus*, and *Nonionina scapha*, all of middling size, and rather common. These also indicate water of moderate depth in a temperate climate. From the shelly Crag of Aldborough we have *Polymorphina lactea* (small and rare), *Rotalia Beccarii* (small and rare), *Polystomella striatopunctata* (middle-sized and common), and *Truncatulina lobatula* (very small, and rather common). These belong, probably, to the beds overlying the Lower Crag, and indicate shallow water. A similar group occurs at Bramerton and Thorpe, in the “Norwich” or “Fluvio-marine Crag,” and also in the Uppermost Crag at Chillesford, which is continued, according to Mr. Searles Wood, jun., over the “Norwich Crag” at Aldborough, Bramerton, and Thorpe.

We have also to notice that among the Foraminifera of the Crag there are some that have been, in all probability, derived from older Tertiary beds; such are *Alveolina*, sp., and *Orbitoides Favjasii*. *Amphistegina vulgaris*, *Nummulina planulata*, and *Operculina complanata* also attract attention as possibly having been washed out from Miocene and Eocene strata. None of these are common; and somewhat imperfect water-worn specimens are all the evidence we have of the two first-named.

Of the Foraminifera of the Upper or Red Crag, we have but a poor supply; indeed, it is not easy to determine in every instance whether we have a *native* or a *derived* fossil in a specimen from the Red Crag, as with this deposit are mixed fossils from the Lower or White Crag, and even from older Tertiary beds. (See Mr. S. V. Wood's memoir on this subject, ‘Quart. Journ. Geol. Soc.’ vol. xv, p. 32, 1858.)

The Foraminifera of the Red Crag indicate a rather shallow sea-zone; they comprise a few common species of *Miliola*, *Polymorphina*, *Textularia*, *Truncatulina*, *Rotalia*, *Calcarina*, *Polystomella*, and *Nonionina*; not abundant as individuals, nor of large size; and are such as live at present in the British Seas, with the exception of *Calcarina*.

The Mammaliferous or Norwich Crag (Thorpe, Southwold, and Bramerton) yields a Rhizopodal fauna somewhat similar to that of the Red Crag.

The few kinds of Foraminifera yielded by the Chillesford Crag, a deposit regarded by Messrs. Wood and Prestwich ('Quart. Journ. Geol. Soc.,' vol. v, p. 350) as probably contemporaneous with the Crag of Norwich (Mammaliferous Crag), by Mr. S. Wood, jun.,¹ as subsequent to it, and by the Rev. O. Fisher² as being older than the Norwich Crag, indicate a rather shallow and cold sea, perhaps somewhat brackish too, as their probable habitat. They are *Polymorphina lactea*, *Bulimina elegans*, *Truncatulina lobatula*, *Rotalia Beccarii*, *Polystomella crispa*, and *P. striato-punctata*. Mr. Prestwich's observations (loc. cit., p. 351) on the probable influence of cold currents from the northern seas on the fossil fauna at Chillesford coincide with the above remarks.

Lastly, some Foraminifera collected by Mr. H. C. Sorby, F.R.S., from the Bridlington Crag³ some years ago, and kindly placed at our disposal, have to be noticed. These comprise *Cornuspira*, *Miliola*, *Lagena*, *Dentalina*, *Cristellaria*, *Polymorphina*, *Cassidulina*, *Truncatulina*, *Polystomella*, and *Nonionina*, and are the most conspicuous of a probably more extensive fauna, nearly allied to that of the Suffolk Crag.

With regard to our treatment of the generic and specific grouping of Foraminifera in this Monograph, having repeatedly stated our views as to the necessity of allowing a wide margin for variation from any central type in determining species amongst the Protozoa, we need not again enter largely upon the subject. Every extension of research tends more and more to show that such characters as surface-markings, form of aperture, number of chambers, and direction of growth—peculiarities upon which not only species and genera, but even families, have been constituted—are individually of little value in forming an estimate of the essential characters of a *species* among Foraminifera. Neither need we repeat what we have before said on the expediency of retaining (with this reservation as to the significance to be attached to them) the binomial appellations that have been given to well-marked varieties, regarded by others as specific forms. We shall have occasion to use them in the course of the Monograph; and, as they will stand in the place of true specific names, we must refer our readers to the Table of Type-species, in the Appendix, for the alliances of these sub-species or varieties. By these remarks, we would not be thought to underrate the value of even trivial external features, such as those alluded to, for they are often of considerable significance both to the Zoologist and the Palæontologist; but only to caution those not practised in inves-

¹ See his paper mentioned at page ii.

² 'Quart. Journ. Geol. Soc.,' vol. xxii, p. 19, 1866.

³ Mr. Bean wrote of the Bridlington Crag in 1835, 'Mag. Nat. Hist.,' vol. viii, p. 355; and Sir C. Lyell in 1839, 'Mag. Nat. Hist.,' new series, vol. iii, p. 313. See also Phillips's 'Geol. Yorkshire,' 1829, vol. i, p. 69; and H. C. Sorby's paper on this Crag, in the 'Proceed. Geol. and Polytech. Soc.,' West Riding, Yorkshire, 1857-8, iii, p. 555. There is also a paper on the Bridlington Crag, by Dr. S. P. Woodward, in the 'Geol. Mag.,' 1864, vol. i, p. 49.

tigations connected with animals of very low organization, that they are not to be regarded as of the same importance as similar, but more permanent, marks would be in higher animals. The difficulty in determining species is enhanced by the fact, that, whilst on the one hand several distinct species may each present varieties so similar that they may be easily confounded, on the other hand the extreme variations in sub-specific forms may at first sight often appear of generic value.¹

With these preliminary remarks we may proceed to the critical examination of the generic and specific forms which have been found in the Crag—endeavouring to distinguish the essential from the non-essential characters, the typical from the aberrant, the specific from individual modifications, and holding in view the same principles of investigation, the adoption of which has led, during recent years, to so great an increase of our knowledge of the group, at the hands of Williamson, Carpenter, Reuss, and others.

¹ We have sometimes thought that a passage in Whewell's 'Philosophy of the Inductive Sciences,' written, it is true, in reference to a far different subject, might have been written, *mutatis mutandis*, with almost equal truth of the nomenclature of the Foraminifera. Speaking of Haüy's nomenclature of the crystals of calcite, he says—"The want of uniformity in the origin and scheme of these denominations would be no valid objection to them if any general truth could be expressed by means of them; but the fact is, there is no definite distinction of these forms. They pass into each other by insensible gradations, and the optical and physical properties which they possess are common to all of them. And, as a mere enunciation of the laws of forms, this terminology is insufficient. Thus it does not at all convey the relation between the *bisalterne* and the *binotenaire*: the former being a combination of the *metastatique* with the *prismatique*; the latter of the *metastatique* with the *contrastante*; again, the *contrastante*, the *mixte*, the *cuboïde*, the *contractée*, the *dilatée*, all contain faces generated by a common law, the index being respectively altered, so as to be in these cases, $3, \frac{2}{3}, \frac{4}{3}, \frac{9}{4}, \frac{5}{9}$; and this, which is the most important geometrical relation of these forms, is not at all recorded or indicated by the nomenclature."

NOTE.—A very valuable memoir on the English and Belgian Crag formations, by Mr. R. Godwin-Austen, F.R.S., has just appeared in the 'Quart. Journ. Geol. Soc. London,' vol. xxii, part 3 (No. 87), p. 229. &c. It is full of important facts and sound philosophic disquisitions.—*August*, 1866.

MONOGRAPH
OF THE
FORAMINIFERA OF THE CRAG.

Class—RHIZOPODA.

Order—RETICULARIA (FORAMINIFERA).

SUB-ORDER—IMPERFORATA.

FAMILY—MILIOLIDA, *Carpenter*.

Genus—CORNUSPIRA, *Schultze*.

ORBIS, *Philippi* (in part).

CORNUSPIRA, *Schultze* (in part).

SPIRILLINA, *Williamson* (in part).

SOLDANIA, *D'Orbigny* (in part).

OPERCULINA, *Czjzek and Reuss* (in part).¹

CORNUSPIRA, *Parker and Jones, Carpenter, Reuss, Brady*.

General characters.—Shell, a flat spire, formed of a simple, non-segmented, and usually unstricted tube, coiled on itself in a horizontal plane, usually cylindrical in the earlier portions of its growth, but becoming wider and flatter as it approaches maturity: white, opake, smooth, and free from ornamentation or surface-markings, except slight transverse ridges, apparently indicating its successive additions during growth. Aperture, terminal; oval or slit-like in shape, according to the extent of flattening which has taken place in the tube.

D'Orbigny, in the 'Annales des Sciences Naturelles,' vol. vii, p. 281, grouped a number of complanate Foraminifera under the generic name *Soldania*. The figures in Soldani's

¹ *Operculina cretacea*, Reuss, Verst. böhm. Kreid., p. 35, pl. 13, figs. 64 and 65 (*Cornuspira cretacea*, Reuss, Sitzungs. K. Ak. Wien., vol. xl, p. 177, pl. 1, fig. 1), seems to be the same as D'Orbigny's *Operculina incerta*, Foram. Cuba, p. 49, pl. 6, figs. 16, 17; and this is a *Trochammina*.

Testaceographia ac Zoophytographia, to which reference is made by him, are unfortunately so diverse in character that no generic group can be founded upon them. Whilst some of the drawings are probably intended for specimens of the genus now under consideration, the others comprise *Cristellaria*, *Nanninella*, and *Planorbina*, so that we are most unwillingly compelled to sacrifice a generic name dedicated to one of the earliest and most persevering students of Microzoa.

Solidana ornata, B. Orb. Ann. Sc. Nat., vol. xii, p. 281, No. 1; Solid., v. App., p. 146, pl. 18, figs. F, G (fossil) = *Cristellaria*.

— *spirobis*, Id. Ibid., No. 2; Solid., Ibid., p. 140, pl. 4, figs. G, H (fossil) = *Nannulina exponens*.

— *urda*, Id. Ibid., No. 3; Solid., id. pl. 135, fig. 1 (fossil) = *Planorbina* [*Planulina*] *truncatensis*.

— *limia*, Id. Ibid., No. 4; Solid., i, p. 62, pl. 53, fig. c (fossil and recent) = *Cornuspira* (?).

— *orbicularis*, Id. Ibid., No. 5; Solid., i, p. 60, pl. 47, fig. H (recent) = *Cornuspira* (?). Both of these have more or less constricted whorls (if correctly drawn).

— *annulata*, Id. Ibid., No. 6; Solid., i, pl. 47, fig. c (recent) = *Serpula* (?).

I. CORNUSPIRA FOLIACEA, *Philippi*. Plate III, figs. 50, 51.

ORBIS FOLIACEUS,¹ *Philippi*, 1844. Enum. Moll. Sicil., vol. ii, p. 147, pl. 24, fig. 26.

OPERCULINA STRIATA, *Czjzek*, 1848. Haidinger's Naturw. Abhandl., vol. ii, p. 146, pl. 13, figs. 10, 11.

— *PLICATA*, Id., 1848. Loc. cit., figs. 12, 13.

CORNUSPIRA PLANORBIS, *Schultze*, 1854. Org. Polyth., p. 40, pl. 2, fig. 21; *Wiegmann's Archiv*, 1860, p. 287; and *Annals Nat. Hist.*, ser. 3, vol. vii, p. 306.

— , *Parker and Jones*, 1857. Ann. Nat. Hist., ser. 2, vol. xix, p. 295.

SPIRILLINA FOLIACEA, *Williamson*, 1858. Rec. Foram. Gt. Brit., p. 91, pl. 7, figs. 199–201.

CORNUSPIRA — *Parker and Jones*, 1860. Quart. Journ. Geol. Soc., vol. xvi, p. 302 (table).

— — *Carpenter*, 1862. Introd. Foram., p. 68, pl. 5, fig. 16.

— — *Brady*, 1864. Linn. Soc. Trans., vol. xxiv, p. 472; 1865, Nat. Hist. Trans., Northumb. and Durham, vol. i, p. 92.

In appending to each typical and varietal form some of the names under which it has been mentioned by previous authors, we have not attempted a complete synonymy. Our rule has rather been to give reference in every case to the description and figures which have the right of priority in nomenclature, to a few of the earlier well-known standard works in general zoology, and to such more modern memoirs as are referred to the Synopsis, and may be easily referred to by the student. Where the number of references has necessitated a selection, those have been preferred with which figures are given. With the subvarietal forms we have given still fewer references. The adoption of this course has been forced upon us by the length to which an exhaustive synonymy would extend. It may be said without doubt, that a complete list of authorities for some such species as the typical *Melania seminulum* would occupy several pages, and would be of little use when finished, except as a curiosity of literature. The plan pursued by Mr. Jeffreys in his admirable work on Conchology,—that of giving only the key to the first description of the species, and a reference to its place in the last standard work on the subject, is an admirable one, but unfortunately not open to us, for want of the standard.

Characters.—Shell, convolute, planodiscoid, thin; the successive whorls becoming gradually, and often rapidly, wider; free from ornamentation, but marked with curved transverse lines of growth. Aperture, in full-grown specimens, a narrow slit, representing the open end of the coiled tube. Diameter $\frac{1}{30}$ th to $\frac{1}{8}$ th inch.

Cornuspira foliacea may be looked upon as the typical form of the genus. It is a beautiful, simple, little shell, inhabiting shallow seas, without much reference to latitude, and commonly attached by its flat surface to Algæ or Zoophytes. Owing to the slightly bi-concave contour, dead specimens, somewhat worn, frequently have the thin central portions broken away; and it is in this condition that our Crag specimens were found. In the northerly British Seas it is an uncommon species; but on our South coast it is more frequent, and specimens in Mr. Jeffreys' collection, dredged off Falmouth, are among the largest we know. It is common in the Arctic Seas, in the Mediterranean, in the South Atlantic, and on the Southern and Western shores of Australia. We cannot trace the species further back in geological time than the Lower Tertiary formations; it abounds in the *Calcaire grossier*, and may be found in almost every subsequent formation. Czjzek's specimens were from the Miocene beds near Vienna, where Reuss has also obtained some varieties (*C. angigyra* and *C. involvens*). The specimens from the Crag were collected by Mr. Searles Wood, at Sutton, where they were found in considerable numbers, and of large size.

2. CORNUSPIRA INVOLVENS, *Reuss*. Plate III, figs. 52—54.

OPERCULINA INVOLVENS, *Reuss*, 1849. Denks. Akad. Wien., vol. i, p. 370, pl. 45, fig. 20.

— — — *Id.*, 1851. Zeits. Deutsch. Geol. Gesel., vol. iii, p. 73.

CORNUSPIRA — — *Id.*, 1863. Sitz. Akad. Wien., vol. xlviii, 1 Abth., p. 39, pl. 1, fig. 2.

Characters.—Shell, free, convoluted, discoidal, bi-concave; formed of a simple unstricted, subcylindrical tube, wound on itself in one plane. Diameter about $\frac{1}{20}$ th inch.

It is convenient to distinguish by a trivial name the thicker variety of *Cornuspira*, in which the tube, forming the spiral, retains to some extent the early, normal, cylindrical form, hollowed a little on its inner side, so that each successive whorl slightly embraces that preceding it.¹ On this ground we admit Professor Reuss's specific term, though we attach no more than subvarietal value to the particular characters possessed by the specimens described. Professor Reuss records the occurrence of this form in the Baden Beds of the Vienna Basin, and at Offenbach and Hermsdorf, Prussia.

¹ Professor Williamson is probably quite right in describing his figure 201, pl. 7, of his 'Monograph,' p. 91, as a young shell of *C. foliacea*, though it consists of "a few narrow rounded convolutions, of equal size," &c.

It is fossil also in New Zealand ('Novara-Expedition, Geol. Theil,' 2 Abtheil., p. 180).

Reuss describes and figures other *Cornuspiræ* (*C. angigyra*, 'Denks. Akad.,' Wien., vol. i, p. 370, pl. 46, fig. 19; *C. polygyra*, 'Sitz. Akad.,' vol. xlviii, p. 39, pl. 1, fig. 1; *C. Bornemanni*, l. c., fig. 3; *C. rugulosa*, 'Sitzungs. Akad.,' vol. xviii, p. 222, pl. 1, fig. 1; *C. Reussi*, Bornemann, 'Denks. Akad.,' vol. xxv, p. 121, pl. 1, fig. 10), from the Tertiary beds of Germany. These, however, as well as *C. Archimedis* and *C. elliptica*, Stache, 'Novara-Expedition, Geol. Theil,' 2 Abth., p. 180, pl. 22, figs. 1 and 2, can only be regarded (zoologically) as varieties of *C. foliacea*. Some, like *C. Hoernesii*, Karrer, may prove to be *Trochammina incerta*.

Genus—MILIOLA, Lamarck.

SERPULA, Linné, Walker and Jacobs, Adams, Maton and Rackett.

VERMICULUM, Montagu, Fleming, Macgillivray, Thorpe.

MILIOLITES, Lamarck, Parkinson.

MILIOLA, Lamarck, Parkinson, Brown, Blainville, Schultze (in part).

MILIOLINA, Williamson (in part).

MILIOLA, Parker and Jones, Carpenter, Brady, &c.

General characters.—Shell, oval or elliptical, composed of segments folded on each other from end to end, in one plane or more, each successive segment larger than the preceding one, and embracing the earlier segments to a greater or less extent. Shell, without true septation, but having a partial constriction in the angle at each change of the direction of growth. Colour, white, opake. Pseudopodial aperture variable in form, terminal.

Upon the mode and extent of the overlapping of the consecutive chambers depends the artificial division of the genus into the subgenera *Uniloculina*, *Biloculina*, *Triloculina* (and *Cruciloculina*), *Quinqueloculina*, and *Spiroloculina*.

Subgenus—BILOCULINA, D'Orbigny.

General characters.—Having only two chambers visible externally, each successive chamber entirely embracing the previous one on the same side.

1. BILOCULINA RINGENS, *Lamarck*. Plate III, figs. 26—28.

MILIOLITES RINGENS, *Lamarck*, 1804. Ann. Mus., vol. v, p. 351; vol. ix, pl. 17, fig. 1.

PYRGO LEVIS, *DeFrance*, 1824. Dict. Sc. Nat., vol. xxxii, p. 273; Atlas, pl. 88, fig. 2.

BILOCULINA BULLOIDES, *D'Orb.*, 1826. Ann. Sc. Nat., vol. vii, p. 297, No. 1, pl. 16, figs. 1-4;
Modèle No. 90.

— RINGENS, *Id.*, 1826. Ann. Sc. Nat., vol. vii, p. 297, No. 2.

— CANARIENSIS, *Id.*, 1839. Foram. Canaries, p. 139, pl. 3, figs. 10-12.

— ISABELLEANA, *Id.*, 1839. For. Amér. MÉR., p. 66, pl. 8, figs. 17-19.

— PERUVIANA, *Id.*, 1839. Foram. Amér. Mérid., p. 68, pl. 9, figs. 1-3 (and
sub-varieties in pl. 8).

— SUBSPHERICA, *Id.*, 1839. Foram. Cuba, p. 162, pl. 8, figs. 25-27.

— BULLATA, *S. Wood*, 1843. Morris's Cat. Brit. Foss., p. 61.

— CLYPEATA, *D'Orb.*, 1846. For. Fos. Vien., p. 263, pl. 15, figs. 19-21.

— SIMPLEX, *Id.*, 1846. Ibid., p. 264, pl. 15, figs. 25-27.

TRILOCULINA BIPARTITA (a badly grown *Biloculina*), *D'Orb.*, 1846. For. Fos. Vien., p. 275,
pl. 17, figs. 1-3.

BILOCULINA RINGENS, *Sow.*, 1850. Dixon's Foss. Sussex, p. 162, pl. 9, fig. 9, *a*.

— TURGIDA, *Reuss*, 1851. Zeitsch. Deutsch. Geol. Ges., vol. iii, p. 85, pl. 7, fig. 55.

— RINGENS, *Parker and Jones*, 1857. Ann. Nat. Hist., ser. 2, vol. xix, p. 298,
pl. 10, figs. 28-33.

— — *Williamson*, 1858. Rec. Foram. Gt. Brit., p. 79, pl. 6, figs. 169, 170;
pl. 7, fig. 171.

— OBESA, *Reuss*, 1865. Sitzungsab. Akad. Wien., vol. I, p. 450, pl. 5, fig. 7.

Characters.—Shell, oval or sub-spherical, ultimate chamber projecting beyond the penultimate all round, and having its margin more or less rounded. Aperture, at the end of the last segment; its shape and size variable, sometimes little more than a curved slit. Length $\frac{1}{50}$ th to $\frac{1}{12}$ th inch.

We may take this as a sub-type, comprising the numberless varieties of *Miliolæ* which show only two chambers externally, the ultimate and the penultimate. The form of the margin, the extent to which the edges of the chambers overlap, the greater or less globosity of the segments, and the shape of the aperture, differ in almost every specimen; and, although the general appearance of the shell is much affected by these variations, they are of no value as characters on which to found any real specific subdivision. It is, however, convenient to recognise some of the most important of the modifications of the ordinary plan of growth, though the very fact of the inconstancy of their characters precludes our viewing them as anything more than varieties; of these, perhaps, *Biloculina elongata*, *D'Orb.*,¹ *B. depressa*, *D'Orb.*, *B. sphaera*, *D'Orb.*,² and *B. contraria*, *D'Orb.*, are the most important.

¹ *Biloculina elongata*, *D'Orb.*, 1826. Ann. Sc. Nat., vol. vii, p. 298, No. 4; *Parker and Jones*, Phil. Trans. 1865, p. 409, pl. 17, figs. 88, 90, 91.

² *B. sphaera*, *D'Orb.*, 1839. Foram. Am. MÉR., p. 66, pl. 8, figs. 13-6; *Brady*, 1864, Trans. Linn. Soc., vol. xxiv, p. 466, pl. 48, fig. 1.

Biloculina ringens is common in almost every sea, abounding all round our own islands. We find it, with most of the other *Miliolæ*, in Tertiary deposits, but not reaching further back than the Eocene beds of the Paris Basin. We find it rare in the Upper Crag, together with its variety *B. elongata*; but in the Sutton Crag it is large and common; and many of the specimens have somewhat narrow but ventricose chambers (fig. 28), tending towards the variety known as *B. contraria*.

Biloculina contraria, D'Orb., which is one of the extreme varietal forms of *B. ringens*, is figured in the 'For. Fos. Vien.,' p. 266, pl. 16, figs. 4—6; and by Brady, 'Trans. Linn. Soc.,' vol. xxiv, p. 246, pl. 48, fig. 2. Some of the sub-varieties, which, like Plate III, fig. 28, form passages between it and *B. ringens*, are—

- Biloculina opposita*, Deshayes, 1831. Coq. Caract. Tert., pp. 252, 259, pl. 3, figs. 8-10; Morris's Cat. Brit. Foss., 1843, p. 61; and 2nd edit., 1854, p. 61.
- *oblonga*, D'Orb., 1839. Foram. Cuba, p. 163, pl. 8, figs. 21-23.
- *Patagonica*, Id., 1839. Foram. Amér. Mér., p. 65, pl. 3, figs. 15-17.
- *irregularis*, Id., 1839. Ibid., p. 67, pl. 8, figs. 20, 21.
- *Bougainvillei*, Id., 1839. Ibid., figs. 22-24.
- *affinis*, Id., 1846. For. Fos. Vien., p. 265, pl. 16, figs. 1-3.

2. BILOCULINA DEPRESSA, D'Orbigny. Plate III, figs. 29, 30.

- BILOCULINA DEPRESSA, D'Orb., 1826. Modèle No. 91; Ann. Sc. Nat., vol. vii, p. 298, No. 1.
- CARINATA, Id., 1839. For. Cuba, p. 148, pl. 8, fig. 24; pl. 9, figs. 1, 2.
- LUNULA, Id., 1846. For. Fos. Vien., p. 264, pl. 15, figs. 22-24.
- UMBONATA, Wood, 1843. Morris's Catal. Brit. Foss., 1st edit., p. 61.
- AMPHICONICA, Reuss, 1850. Denks. Akad. Wien., vol. i, p. 382, pl. 49, fig. 5.
- RINGENS, var. CARINATA, Williamson, 1858. Rec. Foram. Gt. Brit., p. 79, pl. 7, figs. 172-174.
- MILIOLA (BILOCULINA) DEPRESSA, Parker and Jones, 1865. Phil. Trans., vol. clv, p. 409, pl. 17, figs. 89, a, 89, b.

Characters.—Similar to the typical form *B. ringens*, but differing in the more flattened shape of the chambers. Shell lenticular; margin sharp and carinate. Length, $\frac{1}{30}$ th inch.

Biloculina depressa is found in company with the typical *B. ringens*, wherever the latter occurs. The only specimens we have from the Crag are those in Mr. Searles Wood's gatherings from Sutton.

Subgenus—TRILOCULINA, *D'Orbigny*.

General characters.—Having three chambers visible externally; either carinate or rounded.

1. TRILOCULINA TRICARINATA, *D'Orbigny*. Plate III, figs. 33, 34.

TRILOCULINA TRICARINATA, *D'Orb.*, 1826. Modèle No. 94; Ann. des Sc. Nat., vol. vii, p. 299, No. 7.

— — *Brady*, 1864. Trans. Linn. Soc., vol. xxiv, p. 466, pl. 48, fig. 3.

MILIOLA (TRILOCULINA) TRICARINATA, *Parker and Jones*, 1865. Phil. Trans., vol. clv, p. 409, pl. 15, fig. 40.

Characters.—Shell elliptical, angular, having the chambers produced at the margins so as to form three carinate edges. Aperture at the end of the outermost chamber. Length, $\frac{1}{10}$ th inch.

Triloculina trigonula, Lamarck, being regarding as the best sub-type of the Triloculine *Miliolæ*, the sub-variety *T. tricarinata* bears the same relation to it that *Biloculina depressa* does to *B. ringens*; that is to say, it is the form which assumes sharp angular margins, instead of the rounded contour of the sub-type. Mr. Wood found it large and rare at Sutton. The true sub-typical form, though much more widely distributed than this variety, we have nowhere met with in the Crag.

Triloculina tricarinata can scarcely be called a common Foraminifer; for, though it occurs in localities far distant from each other, it is seldom found in any abundance. We have one or two specimens from the British Seas; in deeper water and in more northerly latitudes small specimens are frequent; but perhaps it attains its maximum size and frequency on the Australian coast. Geologically, its occurrence is, so far as we know, confined to the Tertiary formations, commencing in the Eocene deposits of Grignon, in the Paris Basin.

2. TRILOCULINA (QUINQUELOCULINA) OBLONGA, *Montagu*. Plate III, figs. 31, 32.

VERMICULUM OBLONGUM, *Montagu*, 1803. Test. Brit., p. 522, pl. 14, fig. 9.

TRILOCULINA OBLONGA, *D'Orb.*, 1825. Modèle No. 95; Ann. Sc. Nat., vol. vii, p. 300, No. 16.

— — *Id.*, 1839. Foram. de Cuba, p. 175, pl. 10, figs. 3-5.

FORAMINIFERA OF THE CRAG.

- TRILOCULINA EBURNEA, *Id.*, 1839. For. Cuba, p. 180, pl. 10, figs. 21—23.
- MARTIANA, T. CHEMNITZIANA, T. NITIDA, *D'Orb.*, 1839. For. Canar., pl. 3, figs. 16—24.
- CONSOBRINA, *D'Orb.*, 1846. Foram. Foss. Vien., p. 277, pl. 17, figs. 10—12.
- QUINQUELOCULINA MAYERIANA, *Id.*, 1846. For. Foss. Vien., p. 287, pl. 18, figs. 1—3.
- TRILOCULINA MICRODON, *Reuss*, 1850. Denks. Akad. Wien., vol. i, p. 382, pl. 49, fig. 9.
- NITENS, *Id.*, 1850. *Ibid.*, p. 383, pl. 109, fig. 10.
- MILIOLINA SEMINULUM, var. OBLONGA, *Williamson*, 1858. Rec. Foram. Gt. Brit., p. 86, pl. 7, figs. 186, 187.
- TRILOCULINA OBLONGA, *Parker and Jones*, 1857. Ann. Nat. Hist., ser. 2, vol. xix, p. 300, pl. 10, fig. 37; 1859, *ibid.*, ser. 3, vol. iv, p. 343; 1863, vol. xii, p. 437.
- MILIOLA (TRILOCULINA) CONSOBRINA, *Egger*, 1857. Foram. Mioc.-Schicht., p. 10, pl. 2, figs. 7, 8.
- TRILOCULINA OBLONGA, *Brady*, 1864. Trans. Linn. Soc., vol. xxiv, p. 472.
- MILIOLA (QUINQUELOCULINA) OBLONGA, *Parker and Jones*, 1865. Phil. Trans., vol. clv, p. 411, pl. 15, figs. 34—41; pl. 17, 85, *a*, 85, *b*, 86, *a*, 86, *b*.

Characters.—Shell, elongated, compressed, margins of the chambers rounded. Length, $\frac{1}{15}$ th inch.

It is of but little consequence whether we regard this feeble flattened *Miliola* as belonging to the Triloculine or the Quinqueloculine group. In the feeblest forms, which are perhaps the most distinct from the type, it is Triloculine; but examples may easily be found which would form a regular series, passing by insensible gradations to the fully developed *Quinqueloculina seminulum*. The Crag specimens are generally Triloculine; those in Mr. Searles Wood's collection from Sutton are singularly fine; from the Crag with *Cardita senilis* (Gedgrave) we have but one or two small examples. In Mr. Sorby's gatherings from the Bridlington Crag the specimens are numerous, but not so large as those from Sutton.

Triloculina oblonga is found in shallow water, associated with other *Miliolæ*, in seas of every latitude; and minute specimens have been met with, even in abyssal depths, in the North Atlantic (2330 fathoms). We find it in most marine Tertiary clays, but it does not seem to date back further than the Eocene period.

The synonymy of *Miliola seminulum*, var. *oblonga*, is very extensive. This variety accompanies the better marked forms of *Miliola*, and has received very many appellations.

Subgenus—QUINQUELOCULINA, *D'Orbigny*.

General character.—Five chambers visible externally.

1. QUINQUELOCULINA SEMINULUM, *Linné*. Plate III, figs. 35, 36.

- SERPULA SEMINULUM, *Linné*, 1767. Syst. Nat., 12th ed., p. 1264, No. 791.
 — OVALIS, *Adams*, 1800. Trans. Linn. Soc., vol. v, p. 4, pl. 1, figs. 28—30.
 VERMICULUM INTORTUM, *Montagu*, 1803. Test. Brit., p. 502.
 SERPULA SEMINULUM, *Maton and Rackett*, 1807. Trans. Linn. Soc., vol. viii, p. 245.
 VERMICULUM INTORTUM, *Fleming*, 1822. Mem. Wern. Soc., vol. iv, p. 564, pl. 15, fig. 3.
 QUINQUELOCULINA SEMINULUM, *d'Orb.*, 1826. Ann. Sc. Nat., vol. vii, p. 303, No. 44.
 — MERIDIONALIS, *Id.*, 1839. For. Amér. MÉR., p. 75, pl. 4, figs. 1—3,
 10—13.
 — ISABELLEI, *Id.*, 1839. Ibid., p. 74, pl. 4, figs. 17—19.
 — ARAUCANA, *Id.*, 1839. Ibid., p. 76, pl. 9, figs. 13—15.
 — MAGELLANICA, *Id.*, 1839. Ibid., p. 77, pl. 6, figs. 19—21.
 — PAUPERATA, *Id.*, 1846. For. Fos. Vien., p. 286, pl. 17, figs. 22—24.
 — HAUSERINA, *Id.*, 1846. Ibid., p. 286, pl. 17, figs. 25—27.
 — AKNERIANA, *Id.*, 1846. Ibid., p. 290, pl. 18, figs. 16—21.
 — IMPRESSA, *Reuss*, 1851. Zeitschr. Deutsch. Geol. Gesell., vol. viii,
 p. 87, pl. 7, fig. 59.¹
 — SEMINULUM, *Parker and Jones*, 1857. Ann. Nat. Hist., 2nd ser., vol. xix,
 p. 300, pl. 10, figs. 34—36.
 MILIOLINA SEMINULUM, *Williamson*, 1858. Rec. Foram. Gt. Brit., p. 85, pl. 7, figs. 183—
 185.
 QUINQUELOCULINA SEMINULUM, *Brady*, 1864. Trans. Linn. Soc., vol. xxiv, p. 472.
 MILIOLA (QUINQUELOCULINA) SEMINULUM, *Parker and Jones*, 1865. Phil. Trans., vol. clv,
 p. 410, pl. 15, fig. 35a, 35b; pl. 17, fig. 87.

The foregoing are some selected examples from the synonymy of the best form of this species.

Characters.—Shell oblong, sub-compressed; margin rounded; segments ventricose. Colour, white to yellowish-brown. Length, $\frac{1}{15}$ th inch.

The common typical robust *Miliola*, observed by Plancus, Gaultieri, Fabricius, Schröter, and indeed, by nearly all the early authors on marine organisms, was first properly described by Linné, in the tenth edition of the 'Systema Naturæ' (1758), under the name of *Serpula seminulum*. There are perhaps few members of the animal kingdom which have so often received the attention of naturalists, or that have been named and

¹ Figs. 56, 57, 58, of the same plate, seem to be more globose forms of *Q. seminulum*.

re-named so frequently as the little shell now under notice. We may look upon this as the true specific type to which the whole of the varieties of the *Miliolæ* belong, although for convenience we confine the use of the name to the particular form of shell indicated by the general characters above given. As might be supposed, its distribution is world-wide—scarcely a sample of sea-sand, either dredged or littoral, from any quarter of the globe, can be examined without finding specimens of it. In the Crag deposits we have it, in Mr. Searles Wood's collection, from Sutton, very large and common; from Gedgrave and Sudbourne; and from the Red Crag of Essex. From the Bridlington Crag we have many specimens, for which we are indebted to Mr. H. C. Sorby. *Quinqueloculina seminulum* is common in the Grignon Beds of the Paris Basin, and in many subsequent Tertiary strata. Varieties of *Q. seminulum* occur also in the Cretaceous deposits.

2. QUINQUELOCULINA TRIANGULARIS, D'Orbigny. Plate IV, fig. 1.

QUINQUELOCULINA TRIANGULARIS, D'Orb., 1826. Ann. Sc. Nat., vol. vii, p. 302, No. 34.

— — — — — *Id.*, 1846. For. Foss. Vien., p. 288, pl. 18, figs. 7—9.

MILIOLA (QUINQUELOCULINA) SEMINULUM, Parker and Jones, 1865. Phil. Trans., vol. clv, p. 410, pl. 15, figs. 35a, 35b.

Characters.—Shell oval, convex; end-view more or less triangular. Colour, white to yellowish-brown. Length, $\frac{1}{15}$ th inch.

A few large angular Quinqueloculine *Miliolæ* occurring in the Lower Crag of Sutton, together with some smaller specimens from the "Crag with Polyzoa," and others from the Bridlington Crag, seem to claim separation from the typical form, and may be taken together conveniently, with D'Orbigny's name *triangularis*, as a sub-varietal designation.

They present the nearest approach we have in the Quinqueloculine series to the angular condition represented by *Biloculina depressa* and *Triloculina tricarinata*, in their respective subgenera, although the margins of the chambers present somewhat softened angles, rather than any prolongation into carinæ. *Miliolæ* with these characters are to be found in the Mediterranean, the Red Sea, the South Atlantic, the Pacific, and the Indian Oceans, and, as fossils, in the Tertiary clays of the North of Italy, and the Vienna Basin. In some of these localities they appear to take the place of the typical *Miliola* (*Quinqueloculina*) *seminulum*.

Quinqueloculina semiplana, Reuss, 'Zeitsch. Deutsch. Geol. Ges.,' vol. vii, p. 275, pl. 10, fig. 1 (from the Chalk of Mecklenburg), can scarcely be distinguished from *Q. triangularis*.

The difficulty of drawing definite lines among the varieties and sub-varieties of *Miliolæ* will be readily realised, if we endeavour to work out the synonymy of such *Quinqueloculinæ* as are typified by *Q. triangularis*; D'Orbigny's *Q. Lamarchiana* ('For. Cuba,' pl. 11, figs. 14, 15); *Q. Auberiana* (Ibid., pl. 12, figs. 1—3); *Q. Buchiana* ('For. Fos.

Vien.,' pl. 18, figs. 10—12), and very many more noticed by D'Orbigny and others, are mere modifications of *Q. seminulum*, with more or less defined angles.

3. QUINQUELOCULINA SUBROTUNDA, *Montagu*.

SERPULA, *Walker*, 1784. Test. Min., p. 2, pl. 1, fig. 4.

VERMICULUM SUBROTUNDUM, *Montagu*, 1803. Test. Brit., Part 2, p. 521; *Fleming*, 1823, Mem. Wern. Soc., vol. iv., p. 565, pl. 15, fig. 5.

QUINQUELOCULINA SUBROTUNDA, *D'Orb.*, 1826. Ann. Sc. Nat., vol. vii, p. 302, No. 36.

— — — *Wood*, 1843. Morris's Cat. Brit. Foss., p. 63.

— — — SEMINULUM, var. SUBROTUNDA, *Parker and Jones*, 1859. Ann. Nat. Hist., 3rd ser., vol. iv, pp. 336, 341, and 351.

MILIOLA (QUINQUELOCULINA) SUBROTUNDA, *Id.*, 1865. Phil. Trans., vol. clv, p. 411, pl. 15, fig. 38.

Characters.—A small, roundish, bi-convex variety of *Quinqueloculina seminulum*, Linn.

Widely distributed in the Atlantic, if not in other seas, accompanying other *Miliolæ*. Mr. S. Wood found it in the Sutton Crag, and another example occurred to us; but the specimens have been lost.¹

4. QUINQUELOCULINA TENUIS, *Czjzek*.

QUINQUELOCULINA TENUIS, *Czjzek*, 1848. Haid. Abhandl. Wiss., vol. ii, p. 149, pl. 13, figs. 31—34.

— — — *Reuss*, 1851. Zeitsch. Deutsch. Geol. Ges., vol. iii., pl. 7, fig. 60.

MILIOLA (QUINQUELOCULINA) TENUIS, *Parker and Jones*, 1865. Phil. Trans., vol. clv., p. 411, pl. 17, fig. 84.

Characters.—Nearly complanate, but often curved, thin, more or less unsymmetrical; presenting an extreme enfeeblement of *Q. seminulum*, Spiroloculine in aspect, and twisted on itself.

Q. tenuis is small and very rare in the Crag of Sudbourne (specimen lost). It lives in the Atlantic and Mediterranean, at considerable depths. It is fossil in some Tertiary beds of Germany, and in the Lias of England.

¹ We regret much that we have been compelled to make the remark "specimens lost," in connection with several species, one or two of them amongst the rarest of the Crag Foraminifera. We may explain, that quite recently, since the plates which are appended to this Monograph were engraved, we had picked out of our latest gatherings specimens of all the forms which had not been drawn, intending to make from them a fifth plate. The specimens were packed and sent by post, with a view to their being placed in the engraver's hands, but the parcel miscarried; and, notwithstanding the careful inquiries of the Post-Office authorities, which we are bound to acknowledge, it has not been heard of since. Except in the necessary omission of figures, and, in one or two cases, the want of details of measurement, the accuracy of the letter-press is not affected by the loss.

5. QUINQUELOCULINA FERUSSACII, *D'Orbigny*. Plate IV, fig. 4.

QUINQUELOCULINA FERUSSACII, *D'Orb.*, 1826. Modèle No. 32; Ann. Sc. Nat., vol. vii, p. 301, No. 18.

— BERTHELOTIANA, *Id.*, 1839. Foram. Canaries, p. 142, pl. 3, figs. 25—27.

— INÆQUALIS, *Id.*, 1839. Ibid., p. 142, pl. 3, figs. 28—30.

— BICOSTATA, *Id.*, 1840. Foram. Cuba, p. 194, pl. 12, figs. 8—10.

— POLYGONA, *Id.*, 1840. Ibid., p. 198, pl. 12, figs. 21—23.

— TRICARINATA, *Id.*, 1840. Ibid., p. 187, pl. 11, figs. 7—9.

— CONCAVA, *Reuss*, 1850. Denks. Akad. Wien., vol. i, pl. 51, fig. 2.

MILIOLINA BICORNIS, *var.* ANGULATA, *Williamson*, 1858. Rec. For. Gt. Brit., p. 88, pl. 2, fig. 196.

MILIOLA (QUINQUELOCULINA) FERUSSACII, *Parker and Jones*, 1865. Phil. Trans., vol. clv, p. 411, pl. 15, fig. 36.

Characters.—Chambers arranged as in the other *Quinqueloculinae*. Surface of the shell traversed by a few coarse longitudinal ridges. Colour, white to dirty white, or yellowish. Length, $\frac{1}{16}$ th inch.

The assemblage of forms which we associate under the general name *Q. Ferussacii* comprises specimens varying greatly, not only in the extent of the development and overlapping of the segments, and consequently in shape, but also in the amount and nature of the surface-ornamentation. *D'Orbigny's* Modèle No. 32, is a thick elongated *Miliola*, with a very few stout longitudinal ridges at irregular intervals, and at first sight will be thought a very different form from that which we figure. We shall therefore enumerate a few of the more important varieties which have been named by other observers, in order to show the great range of variation which exists amongst members of the group. In *D'Orbigny's* 'Cuba' Monograph we find *Quinqueloculina bicostata* and *Q. polygona*, both of which have almost exactly the characters of the "Model," and in *Q. tricarinata* we have what is evidently an anomalous specimen of the same variety, differing from the others chiefly in the confused setting-on of the ribs, which are partly in longitudinal lines, and partly reticulated or looped. In his South-American work there are interesting figures of two sub-varietal forms, both of which possess an ornamentation of fine striæ, in addition to the main angular ridges; one of these, *Q. flexuosa* (p. 73, pl. 4, figs. 4—6), has the striæ running in an oblique direction; in the other, *Q. Inca* (p. 75, pl. 4, figs. 20—22), they are parallel with the ridges. Some other slightly differentiated forms, tending in the direction of the *Spiroloculine* series, have been figured; and, were we to take certain of the so-called *Spiroloculinae*, such as *Sp. cymbium* (*D'Orb.*), we should find it impossible to describe them by any zoological term which would not apply equally well to many specimens of the form now under consideration; indeed, the inosculation is so complete, as to render any specific (not to say generic) distinction impracticable, however necessary it may be for the sake of convenience to recognise the artificial division of the family. The single specimen (Plate IV, fig. 4) from the Crag is one of the out-spread

varieties, not far removed from the transitional forms above alluded to; the ridged marginal border being almost the only character connecting it with *Q. Ferussacii*.

It is very difficult, therefore, if not impossible, to define the limits of this variety, which passes into the true *Q. seminulum* on one hand, and into several varieties (of little value) on the other. The synonyms above given are merely a selection.

Stout-ribbed *Quinqueloculina* are not uncommon wherever the other *Miliolæ* exist, though they seldom occur in any great abundance; we find their shells also in fossiliferous Tertiary strata in the neighbourhoods of Paris and in the Vienna Basin. In the Crag we only note its occurrence at Sutton.

6. *QUINQUELOCULINA PULCHELLA*, *D'Orbigny*. Plate IV, fig. 3.

QUINQUELOCULINA PULCHELLA, *D'Orb.*, 1826. *Ann. Sc. Nat.*, vol. vii, p. 303, No. 42;
Soldani, *Testac. ac. Zooph.*, vol. iv, p. 53, pl. 18,
figs. *c* and *f*.

— *VERNEUILIANA*, *SCHREIBERSII*, *JOSEPHIANA*, *Id.*, 1846. *For. Foss.*
Vien., p. 296, pl. 19, figs. 19—27.

— *PULCHELLA*, *Brady*, 1864. *Trans. Linn. Soc.*, vol. xxiv, p. 466, pl. 48,
fig. 4.

Characters.—Shell traversed by several stout parallel longitudinal costæ. Segments arranged as in the other *Quinqueloculina*. Colour white, dirty-white, or brownish. Length, $\frac{1}{15}$ th inch.

The varying conditions of the surface of the shell in respect to texture and ornamentation are among the least of the secondary characters on which the artificial subdivision of the Milioline groups may be founded. These characters cannot boast any greater permanency than we have ascribed to those on which the larger divisions have been determined. The texture of the normally porcellaneous Foraminiferal shells may, under altered circumstances, present every gradation from white and smooth to brown, rough, and purely arenaceous; and the surface-markings, which so many species exhibit, are seen in every degree of intensity, from delicate hair-like striæ and fine riblets, to deep sulcations and bar-like ribs. But, whilst it is impossible to draw any defined limit between these different forms of ornamentation, they are sufficiently striking in their external development to yield a ready means of dividing what would otherwise be a somewhat unwieldy and heterogeneous collection of forms.

The bold and strongly ribbed *Quinqueloculina pulchella* is not a common shell; and only a single specimen has occurred to us in our examination of the Foraminifera of the Crag. This specimen, from Sutton, is in Mr. Searles Wood's collection; and although it is broken and much worn, we have no hesitation in assigning it to this sub-species. On the British coast, *Q. pulchella* is a very rare form; but it is more frequent in the Mediterranean, and in tropical seas. It is occasionally found in the Tertiary fossiliferous deposits, but does not appear before the Grignon Beds of the Paris Basin.

7. QUINQUELOCULINA BRONGNIARTII, *D'Orbigny*, Plate III, figs. 41, 42 ; Plate IV, fig. 2.

- POLLONTES VESICULARIS, *Montfort*, 1808. *Conch. Syst.*, vol. i, p. 246.
- ADELISINA STRIATA (young *Q. Brongniartii*), *D'Orb.*, 1826. *Modèle* No. 18 ("young"), No. 97 ("adult") ; *Ann. Sc. Nat.*, vol. vii, p. 304, No. 2.
- TRILOCULINA BRONGNIARTII, *D'Orb.*, 1826. *Ann. Sc. Nat.*, vol. vii, p. 300, No. 23 ; *Soldani*, *Testac. Zooph.*, vol. iii, p. 229, pl. 154, figs. *bb*, *cc*, *dd*, *ee*, *ff*, *gg*.
- — *Id.*, 1839. *Foram. Cuba*, p. 176, pl. 10, figs. 6—8.
- QUINQUELOCULINA GUANCHA, *Id.*, 1839. *Foram. Canaries*, p. 143, pl. 3, figs. 34—36.
- PARTSCHII, *Id.*, 1846. *For. Fos. Vien.*, p. 293, pl. 19, figs. 4—5.
- BOUEANA, *Id.*, 1846. *Ibid.*, p. 293, pl. 19, figs. 7—9.
- DUTEMPLEI, *Id.*, 1846. *Ibid.*, p. 294, pl. 19, figs. 10—12.
- NUSSDORFIENSIS, *Id.*, 1846. *Ibid.*, p. 295, pl. 19, figs. 13—15.
- TRILOCULINA DICHOTOMA, *Reuss*, 1850. *Denks. Akad. Wien.*, vol. i, p. 383, pl. 49, fig. 12.
- QUINQUELOCULINA STRIOLATA, *Id.*, 1850. *Ibid.*, vol. i, p. 385, pl. 50, fig. 10.
- ADELISINA CRETACEA, *Id.*, 1851. *Haiding. Naturw. Abhandl.*, vol. iv, p. 46, pl. 5, fig. 15.
- QUINQUELOCULINA BRONGNIARTII, *Parker and Jones*, 1860. *Ann. Nat. Hist.*, ser. 3, vol. vi, p. 344.

Characters.—Shell having a surface-ornamentation of delicate, parallel, longitudinal striæ. Segments arranged as in the other Quinqueloculine *Miliolæ*. Colour white to yellowish. Length, $\frac{1}{16}$ th to $\frac{1}{10}$ th inch.

The finely striated *Miliolæ* included under this sub-varietal term may be found in every condition, from that approaching the common smooth unornamented shell, in which but a few short lines appear at the base of the penultimate chamber, as in Plate IV, fig. 2 (a condition represented to some extent in *D'Orbigny's* 'Modèles' Nos. 18 and 97), to that in which the whole of the surface is covered by delicate hair-like markings.

Mr. Wood's collection contains but a few specimens from Sutton, and we have not noticed the variety in the other Crag deposits. We have never seen examples having precisely the characters of *Q. Brongniartii* from our own coast, though we have a fair approach to it in some specimens of *Q. bicornis*, in which, though the marking is analogous, the shape of the shell is sufficiently distinct to justify separation. We find it occasionally in the Mediterranean, and in most shallow-water-dredgings from tropical seas. In the Tertiary clays of the North of Italy, in the Miocene of the Vienna Basin, and in the Eocene of the Paris Basin, it is also sparingly found.

Subgenus—SPIROLOCULINA, D'Orbigny.

General characters.—Shell consisting of numerous segments arranged spirally on one plane. Segments scarcely embracing, so that the whole number are visible on both lateral faces.

1. SPIROLOCULINA PLANULATA, *Lamarck*. Plate III, figs. 37, 38.

- MILIOLITES PLANULATA, *Lam.*, 1805. Ann. Mus., vol. v, p. 352, No. 4.
 MILIOLA — *Defr.*, 1824. Dict. Nat. Sc., xxi, p. 68.
 SPIROLOCULINA DEPRESSA, *D'Orb.*, 1826. Modèle No. 92. Ann. Sc. Nat., vol. vii, p. 298, No. 1; *Soldani*, Test. Zooph., vol. iii, p. 229, pl. 155, figs. *k k*.
 — BADENENSIS, *Id.*, 1846. For. Foss. Vien., p. 270, pl. 16, figs. 13—15.
 — DILATATA, *Id.*, 1846. Ib., p. 271, pl. 16, figs. 16—18.
 — EXCAVATA, *Id.*, 1846. Ib., figs. 19—21.
 — CONCENTRICA, *S. Wood*, 1843. Morris's Cat. Brit. Foss., p. 64.
 — DEPRESSA, *Jones*, 1854. Ib., 2nd edit., p. 43.
 — — var. ROTUNDATA, *Williamson*, 1858. Rec. For. Gt. Brit., p. 82, pl. 7, fig. 178.
 — PLANULATA, *Parker and Jones*, 1860. Ann. N. Hist., 3rd ser., vol. v, p. 466; *P. J. and Brady*, 1865, ib., vol. xvi, p. 33.

Characters.—Shell elliptical or oblong, complanate; chambers all visible; margins more or less rounded. Length, $\frac{1}{9}$ th inch.

This is the central, sub-typical form of the *Spiroloculinae*. Amongst the fine bold specimens belonging to this group there is less variation from the normal condition than in any other of the Milioline sub-genera. The chief deviations which we find are those arising from feeble growth, giving rise to an elongated starved condition of the shell; or, as a result of rapid development from very small central chamber, an extremely bi-concave form in the adult. There are also occasional irregularities in the contour of the shell, from the much curved or sigmoidal growth of the chambers, and from the hollowing of their lateral faces; but the absence of surface-marking from the entire group lessens the number of varieties requiring trivial names.

Spiroloculina planulata is common in the Sutton Crag, and the specimens obtained from that source are of good size and of coarse growth. From the Polyzoan Crag we have seen only a few small examples. Geologically, *Spiroloculinae* appear amongst the

earliest of *Miliolæ*, if not the first of all in point of time. A feeble variety of the form now under consideration is found in the Lower Lias Clay of Warwickshire; and it occurs, associated with the other *Miliolæ*, in nearly if not quite all the Tertiary strata that yield Foraminifers.

It is a very common form at all depths in the British seas, and partakes of the cosmopolitan character of the other sub-typical forms of the family.

2. SPIROLOCULINA CANALICULATA, *D'Orbigny*. Plate III, figs. 39, 40.

- SPIROLOCULINA CYMBIUM, *D'Orb.*, 1839. Foram. Canar., p. 140, pl. 3, figs. 5, 6.
 — CANALICULATA, *Id.*, 1846. For. Foss. Vien., p. 269, pl. 16, figs. 10—12.
 — LIMBATA, *Bornemann* (non *D'Orb.*), 1855. Zeitsch. Deutsch., Geol. Ges.,
 vol. vii, p. 44, pl. 8, fig. 1; *Reuss*, 1863, Sitz. Akad. Wien.,
 vol. xlviii, p. 64, pl. 8, fig. 89.
 — DEPRESSA, et var. CYMBIUM, *Williamson*, 1858. Rec. For. Gt. Brit., p. 82,
 pl. 7, figs. 177, 179.
 — CANALICULATA, *Parker and Jones*, 1862. App. Carpenter's Introd. For.,
 p. 312, pl. 6, fig. 2.

Characters.—Segments arranged as in the other *Spiroloculinæ*. Lateral faces of the chambers concave, in extreme examples the peripheral margins bearing a groove due to the prominence of the marginal ridges. Length, $\frac{1}{12}$ th inch.

We prefer retaining the trivial name used in *D'Orbigny's* Monograph on the Foraminifers of the "Vienna Basin," in preference to the earlier one employed in his work on the Foraminifera of the Canaries, inasmuch as the figures to which it is applied indicate a shell of medium growth, and therefore more typical in character, and a better representative of the little group to which both varieties pertain. The figured variety in the latter work, *Sp. cymbium*, is one of the feeble and perhaps transitional forms, concerning many of which it is difficult to say whether they belong to the Spiroloculine or the Quinqueloculine sub-types. In *Sp. canaliculata* each chamber is more or less bi-concave; and in its extreme development the marginal ridges become very prominent, producing a well-marked marginal groove on the peripheral edge of the shell.

In the Lower Crag of Sutton we have many large specimens; but we are not able to speak of its occurrence in the Crag of other localities. Recent specimens are not uncommon; indeed, it may be said to occur wherever Spiroloculine *Miliolæ* are found, whether in shallow seas, or in fossiliferous beds formed under similar circumstances.

Genus—PENEROPLIS, *De Montfort*.NAUTILUS, *Forskål, Spengler, Linné, Gmelin, Batsch, Fichtel and Moll.*SPIROLINA and CRISTELLARIA, *Lamarck.*PENEROPLIS, *De Montfort, De Blainville, D'Orbigny, Carpenter, &c.*

General characters.—Shell free, equilateral, regular, more or less nautiloid. Form very variable; lenticular, outspread, or crozier-shaped. Surface usually obliquely striated. Each convolution formed of numerous narrow undivided segments. The outer whorl embracing those within it, and in the complanate varieties almost concealing them. Apertures variable, either single (in young shells) or numerous and distinct, or else taking the form of one large dendritic orifice caused by the coalescing of a linear series of pores.

Subgenus—DENDRITINA, *D'Orbigny*.

General characters.—Shell nautiloid, lenticular, turgid. Pseudopodial aperture large, irregular, dendritic.

1. DENDRITINA ARBUSCULA, *D'Orbigny*. Plate III, figs. 48, 49.

DENDRITINA ARBUSCULA, *D'Orb.*, 1826. Modèle No. 21. Ann. de Sc. Nat., vol. vii, p. 285, No. 1, pl. 15, figs. 6, 7.

PENEROPLIS PLANATUS (*F. and M.*), var., *Carpenter*, 1859. Phil. Trans., vol. cxlix, p. 9, pl. 2; Introd. For., p. 88, pl. 8.

Characters.—Shell nautiloid, turgid, thickened at the umbilicus, rounded more or less at the margin. Aperture a single large ramifying orifice, formed by the coalescence of numerous small pores, arranged either in a line or otherwise. Diameter, $\frac{1}{10}$ th inch.

In speaking of the earlier authors who have studied the different forms of *Peneroplis* ('Ann. Nat. Hist.,' March, 1865), we have stated our views fully as to the value of the subdivision of the type into genera and species. (See also Carpenter's memoir, 'Phil. Trans.,' 1859, and his 'Introd. Foram.,' p. 84.) Notwithstanding the wide variations in general contour, and in the nature of the pseudopodial apertures which may be observed in different specimens, there can be no doubt that the whole constitute but one true species. At the same time we are able to divide them roughly, according to the nature of their divergence from the central type, into three or four groups, for which, as causing least confusion, we propose to keep the well-known and hitherto accepted names, giving to them a subgeneric place. Of these groups, that centering in *Peneroplis* (*Dendritina*)

arbuscula is one of the most interesting in a zoological point of view; and the careful study of its peculiarities has been one of the chief means of reducing to a proper level the exaggerated views held by M. D'Orbigny and others as to the value of the form and character of the pseudopodial apertures in the determination of species amongst the Rhizopods. Dr. Carpenter has entered very fully into this question ('Phil. Trans.,' 1859; and 'Introduction,' pp. 88—91), and all who have had the opportunity of examining large numbers of specimens will agree in his conclusions.

Dendritina Antillarum, D'Orb., 1839, 'Foram. Cuba,' p. 58, pl. 7, figs. 3—6; and *D. Hauerii*, *D. Juleana*, and *D. elegans*, D'Orb., 'For. Foss. Vien.,' p. 134, pl. 7, figs. 1—6, are but slightly modified forms, or rather variously conditioned individuals, of the nautiloid *Peneroplis* under consideration.

Dendritina arbuscula has not so wide a distribution as the other varieties of *Peneroplis*, and the specimens are generally smaller than those of the outspread varieties. It has its home in shallow seas in tropical latitudes; and it is abundant in some parts of the Adriatic and Mediterranean. In the Tertiary beds it is occasionally met with as low as the Miocene of Bordeaux, the Oligocene of Germany, and even the Eocene of the Paris Basin.

The specimen figured by us from the Crag is, we believe, unique, and has a somewhat worn appearance. It is either from Sudbourne or Gedgrave.

Subgenus—SPIROLINA CYLINDRACEA, *Lamarck*.

- SPIROLINA (SPIROLINITES) CYLINDRACEA, *Lamarck*, 1804. Ann. Mus., vol. v, p. 245, No. 2;
1806, *ibid.*, vol. viii, p. 388, pl. 62, fig. 15;
1816, Tabl. Enc. Méth., part 23, pl. 465, fig.
7 *a-c*, and pl. 466, fig. 2, *a, b*; 1822, Hist.
Anim. s. Vert., vol. vii, p. 603, No. 2.
- SPIRULA CYLINDRACEA, *Blainville*, 1824. Dict. Sc. N., vol. xxxii, p. 190; Malacol., p. 382,
pl. 5, fig. 1.
- SPIROLINA CYLINDRACEA, *D'Orb.*, 1826. Modèle, No. 24; Ann. Sc. Nat., vol. vii, p. 286, No. 1.
— (et SPIROLINITES) CYLINDRACEA, *Defr.*, 1827. Dict. Sc. Nat., vol. 1, p. 298,
pl. 13, fig. 1.
- CLAVATA, *Couch*, 1827. Illust. Introd. Lam. Conch, p. 40, pl. 20, fig. 8.
- CYLINDRACEA, *Bronn*, 1838. Leth. Geog., vol. ii, p. 1135, pl. 42, fig. 24.
- et PENEROPLIS, var., *Carpenter*, 1859. Phil. Tr., vol. cxlix, pl. 2, fig. 11; 1862,
Introd., p. 88, pl. 7, fig. 4.
- PENEROPLIS PLANATUS (F. and M.), var., *Parker and Jones*, 1859. Ann. Nat. Hist., ser. 3,
vol. iii, p. 481; 1860, *ibid.*, vol. v, p. 466.
- PERTUSUS (Forsk.),¹ var., *Parker, Jones, and Brady*, 1865. *Ibid.*, vol. xv,
pp. 231, 232.
- SPIROLINA CYLINDRACEA (Lam), *P. J. and B.*, 1865. *Ibid.*, vol. xvi, p. 22.

¹ The wide variation in character presented specimens referable to the Peneroplid type has caused

General characters.—Numerous short, subcylindrical chambers, forming a long linear shell, of variable dimensions, truncate at one end, and perforated with either a single (often dendritic) aperture, or with several pores; and at the other (first-formed) end curled into a little crook or knob: this, when small, is often broken off, leaving a tapering, awl-shaped, striated shell, delicate in shape and white in colour.

Sp. cylindracea is common in the Mediterranean, Red, and Indian Seas. We have it small and very rare from the Crag of Sudbourne (specimen lost).

much confusion in the nomenclature; and it will be useful here to point out some of the best-marked forms of *Peneroplis* and its varieties, in chronological order:—

1775. NAUTILUS PERTUSUS, *Forskål* (type: comprising broad and narrow varieties). *Peneroplis pertusus*, *Forsk.*
1781. — RECTUS, *Spengler* (including a variety of *Articulina*).
1785. — UMBILICATUS, *Linné* (flat, curled like a crozier-head). *Peneroplis umbilicatus*, *Linn.*
1785. — SEMILITUUS, *Linné* (flat, with crozier-head and short stem). *Peneroplis semilituus*, *Linn.*
1788. — LITUUS, *Gmelin* (long, slender, cylindric, with one end curled). *P. (Spirolina) lituus*, *Gm.*
1791. — (LITUUS) ARIETINUS, *Batsch* (narrow, flat, curled at end). *P. arietinus*, *Batsch.*
1791. — — ACICULARIS, *Id.* *P. (Spirolina) lituus*, *Gm.*
1803. — PLANATUS, *Fichtel and Moll.* (broad forms). *P. planatus*, *F. and M.*
1804. SPIROLINA (SPIROLINITES) DEPRESSA, *Lamarck* (two subvarietal forms; one nearly lenticular, *Dendritina?*). *P. pertusus*, *Forsk.*
1804. — — CYLINDRACEA, *Id.* (long, sub-cylindrical, with one end curled). *P. (Spirolina) cylindracea*, *Lam.*
1808. PENEROPLIS LANATUS, *Montfort.* *P. planatus*, *F. and M.*
1816. CRISTELLARIA PLANATA, *Cr. dilatata*, *Lamarck*; and 1822, *Cr. squamula*, *Lam.* *P. planatus*, *F. and M.*
1826. DENDRITINA ARBUSCULA, *D'Orb.* (lenticular). *P. (Dendritina) arbuscula*, *D'Orb.*
1839. COSCINOSPIRA (SPIROLINA) HEMPRICHII, *Ehrenberg* (stout, cylindric, with boldly curved end). *P. (Spirolina) cylindracea*, *Lam.*

Although *Forskål* did not figure *P. pertusus*, yet there can be no mistake in regarding the following description as especially belonging to it ('Descript. Anim. Itin. Orient.,' 1775, p. 125): "Having compressed whorls, transversely sulcated, and marked with slight longitudinal striæ; at the aperture perforated with pores. Colour snow-white. . . . Whorls straight at the base [top], often dilated, sometimes linear; at the apex [earliest part] convolutely spiral." It was from Suez, Red Sea.

Genus—ORBICULINA, *Lamarck*.NAUTILUS, *Fichtel* and *Moll*.ORBICULINA, *Lamarck*.ARCHAIAS, HELENIS, and ILOTUS, *De Montfort*.ORBICULINA, *Lamarck*, *De Blainville*, *D'Orbigny*, *Williamson*, *Carpenter*, &c.

General characters.—Shell complanate, ear-shaped, sub-orbicular, or discoidal, usually thickened at the umbilicus. In typical specimens the plan of growth is spiral, frequently changing to cyclical, especially in large specimens. Septal bands narrow; chambers usually divided into chamberlets. Pseudopodial apertures in one or more rows on the peripheral margin of the last chamber.

1. ORBICULINA ADUNCA, *Fichtel* and *Moll*. Plate III, fig. 44.

- NAUTILUS ADUNCUS (adult), *Fichtel* and *Moll*, 1803. Test. Microsc., p. 115, pl. 23, figs. *a—e*.
 — ORBICULUS (middle-aged), *Id.*, 1803. *Ib.*, p. 112, pl. 21, figs. *a—d*.
 — ANGULATUS (young), *Fichtel* and *Moll*, 1803. *Ib.*, p. 113, pl. 22, figs. *a—e*.
 ARCHAIAS SPIRANS (= O. ANGULATA), *Montfort*, 1808. Conchyl. Syst., p. 190.
 ILOTES ROTALITATUS (= O. ORBICULUS), *Id.* *Ib.*, p. 198.
 HELENIS SPATOSUS (= O. ADUNCA), *Id.* *Ib.*, p. 194.
 ORBICULINA ADUNCA, *Lamarck*, 1816. Tabl. Encycl. Méth., pt. 23, pl. 468, fig. 2.
 — ANGULATA, *Id.* *Ib.*, fig. 3.
 — NUMMATA (= O. ORBICULUS), *Id.* *Ib.*, fig. 1.
 — NUMISMALIS — *Id.*, 1822. Anim. s. Vert., p. 609, No. 1.
 — ANGULATA, *Id.* *Ib.*, No. 2.
 — UNCINATA (= O. ADUNCA), *Id.* *Ib.*, No. 3.
 — ADUNCA
 — ANGULATA } *De Blainville*, 1824. Dict. Sc. Nat., vol. xxxii; and Malacologie,
 — NUMISMALIS } pp. 373-375, after *Lamarck*.
 — NUMMATA }
 — NUMISMALIS, *D'Orb.*, 1826. Modèle No. 20; Ann. Sc. Nat., vol. vii, p. 305, No. 1.
 — — *Ehrenberg*, 1838. Abhand. Akad. Berlin., 1839, pl. 3, fig. 1.
 — ADUNCA, *D'Orb.*, 1840. Foram. Cuba, p. 64, pl. 8, figs. 8—16.
 — — *Williamson*, 1851. Trans. Micr. Soc. Lond., 1st ser., vol. iii, p. 105.
 — — *Carpenter*, 1856. Phil. Trans., vol. cxlvi, p. 547, pl. 28, figs. 1—22,
 and pl. 29, figs. 1—3.
 — — *Parker* and *Jones*, 1860. Ann. Nat. Hist., 3rd ser., vol. v, p. 181.
 — — *Carpenter*, 1862. Introd. Foram., p. 93, pl. 8, figs. 1—12.

Characters.—Shell ear-shaped, reniform, or orbicular, compressed, thickened at the umbilicus. Chambers arranged spirally, usually divided into chamberlets. Pseudopodial orifices in one or more rows on the peripheral edge of the last chamber. Surface of the chamber frequently marked by delicate parallel transverse riblets.

Diameter, $\frac{1}{30}$ th to $\frac{1}{8}$ th inch.

Orbiculina flourishes in warm seas, but seems to be very rare in the Mediterranean. It is sparingly found in some of the European Tertiaries. Only one specimen, small and reniform, has occurred to us from the Crag (Sutton?).

2. ORBICULINA COMPRESSA, *D'Orbigny*. Plate III, fig. 43.

ORBICULINA COMPRESSA, *D'Orb.*, 1840. Foram. Cuba, p. 66, pl. 8, figs. 4—7.

ORBITOLITES COSCINODISCUS, *S. Wood*, 1843. Morris's Cat. Brit. Foss., p. 42; 1844, Mag. N. Hist., vol. xiii, p. 21.

— (?) — *Id.* 1854. Morris's Cat. Brit. Foss., 2nd edit., p. 39.

Characters.—Shell complanate, discoidal. Earlier chambers arranged spirally, as in the type, later chambers cyclical. Chambers subdivided into chamberlets.

Diameter, $\frac{1}{5}$ th inch.

Although in localities where *Orbiculina* are plentiful, specimens of a large size are often found retaining the spiral arrangement throughout their whole series of chambers, we more frequently find that those which attain the finest proportions have assumed an outspread discoidal form, in place of the ear-like or reniform shape, owing to the alteration in the plan of development before alluded to. When this change commences, as is often the case after a very few chambers have been formed, a thickening of the umbilicus is almost the only external character which will enable us to separate the specimens from those of the closely allied genus *Orbitolites*, and even this feature may be wanting. Microscopical examination of the central or umbilical portion of the disk usually yields a ready means of determining the affinities of doubtful specimens in the arrangement of the early chambers. *Orbiculina* has invariably a nucleus of spirally arranged segments, however large and outspread the finely grown specimen may be; whilst *Orbitolites*, commencing growth with one or two large chambers, is built up entirely of concentric bands, in even the smallest and most obscure examples.

Specimens of *O. compressa* were not rare in the Crag at Sutton some years ago, when worked at by Mr. Wood. The figured specimen is of large size, but somewhat worn and broken.

Mr. Wood, in his "Catalogue of the Zoophytes from the Crag," 'Mag. Nat. Hist.,' 1844, vol. xiii, p. 21, describes, under the name of *Orbitolites coscinodiscus*, some specimens of this Foraminifer obtained at Ramsholt and Sutton. It is there stated that

the cells differ in form and arrangement from those of *Orbitolites complanata*; but the general form of the shell suggested *Orbitolites* for its genus. *Orbiculina compressa* is indeed an isomorph of the well-known *O. complanata* (more properly *O. orbiculus*); and in some instances they are with difficulty separated.

In distribution this variety is associated with the typical species; wherever the latter occurs abundantly we see the tendency in the bolder specimens to take the characters assigned to *O. compressa*.

In the spiral form of *Orbiculina* we recognise the type of a series of large-sized discoid Foraminifera common in tropical seas. The great diversity in appearance presented by different mature specimens, and the alterations which take place from time to time in the mode of growth of the shell, caused considerable confusion amongst the earlier writers, and were the cause of much unnecessary division into "species." D'Orbigny, in his 'Tableau Méthodique,' and subsequently in the 'Cuba' Monograph, somewhat simplified the nomenclature, by uniting the species founded by Lamarck, De Montfort, and others, which were, in some cases, nothing else than the young, middle-aged, and adult of the same variety; but it was not until Professor Williamson, in 1851, published his researches on the minute structure of the shell that the correct relations of the forms was understood. No true specific difference exists between the specimens whose entire growth is on a flat spiral plan and those which ultimately assume a discoidal form by the alteration, after partial development, to a cyclical mode of increase; neither has any principle been found to account for this taking place. Another very variable character in the species is the condition of the chambers in regard to subdivision. In well-formed individuals each chamber is divided into chamberlets by transverse partitions; but we frequently find, especially in small or poor specimens, the chambers simple, and free from any partition or constriction. The surface of the shell normally exhibits a certain amount of surface-marking in the form of delicate parallel riblets, running in a transverse or oblique direction to the chambers, very similar to those of *Peneroplis*; but this, again, is by no means a constant character.

Genus—ORBITOLITES, Lamarck.

NAUTILUS, *Forskål.*

ORBITOLITES et ORBULITES (parte), *Lamarck.*

DISCOLITHUS, *Fortis.*

DISCOLITES, *Montfort.*

MARGINOPORA, *Quoy and Gaimard.*

SORITES et AMPHISORUS, *Ehrenberg.*

ORBITOLITES, *DeFrance, D'Orbigny, Carpenter, Parker and Jones, &c.*

General characters.—Shell a flat, circular disk, composed of one or more layers of concentric zones arranged around a central or primordial portion. Each zone or chamber subdivided by depressions in the shell wall (marked externally by surface furrows) into ovate or rectangular chambers, whose long diameter is in the direction of radii. Pseudopodial orifices situated in depressions on the lateral face of the peripheral chamber. Texture porcellanous, diaphanous.

1. ORBITOLITES ORBICULUS, *Forskål.* Plate III, figs. 45—47.

Umbilicus marinus, *Plançus*, 1744. Fab. Columnæ Lync. Phytobas. Addit. p. 136, pl. 38, fig. F.

Helicite et Opercule, *Guettard*, 1770. Mém., vol. iii, p. 434, pl. 13, figs. 30—32.

NAUTILUS ORBICULUS, *Forskål*, 1775. Descrip. Anim., p. 125, No. 66.

ORBITOLITES COMPLANATA, *Lamarck*, 1801. Syst. Anim. s. Vert., p. 376.

DISCOLITHUS X., *Fortis*, 1802. Mém. Hist. Nat., vol. ii, p. 111, pl. 3, figs. 4, 5.

Madrepore, *Deluc*, 1803. Journ. Phys., vol. lvi, p. 349, fig. 9.

DISCOLITES CONCENTRICUS, *Montfort*, 1808. Conchyl. Systém., vol. i, p. 186.

ORBITOLITES PLANA, *Brongniart and Cuvier*, 1808. Ossem. Foss., vol. ii, part 2, p. 270.

ORBULITES MARGINALIS, O. COMPLANATA, *Lamarck*, 1816. Anim. s. Vert., vol. ii, p. 196, Nos. 1, 2.

ORBITOLITES COMPLANATA, *Schweigger*, 1819. Beobacht., pl. 6, fig. 60.

ORBULITES PLANULATUS, *Blainville*, 1825. Dict. Sc. Nat., xxxvi, p. 294; Atlas Zooph., pl. 47, fig. 2; Actinologie, p. 441, pl. 72, fig. 2.

— MARGINALIS, O. COMPLANATA, *Lamouroux*, 1821. Gen. Polyp., pp. 44, 45, pl. 73, figs. 13—16.

ORBITOLITES COMPLANATA, *DeFrance*, 1825. Dict. Sc. Nat., xxxvi, p. 294.

— — *Bronn*, 1825. Syst. Urwelt. Pflanz., pl. 6, fig. 18; 1838, Leth. Geogn. pl. 35, fig. 22.

SORITES ORBICULUS, *Ehrenberg*, 1838. Berlin Trans. (1839), p. 112, pl. 3, fig. 2.

AMPHISORUS HEMPRICHII, *Ehrenberg*, 1838. Ib., p. 114, pl. 3, fig. 3.

ORBITOLITES COMPLANATA, O. ELLIPTICA, *Michelin*, 1840—45. Icon. Zooph., p. 167, pl. 46, fig. 4, and p. 277, pl. 61, fig. 11.

— — *Carpenter*, 1850. Quart. Journ. Geol. Soc., vol. vi, p. 30, pl. 6, fig. 23; pl. 7, figs. 24—30.

ORBICULINA (ORBITOLITES) COMPLANATA, *Williamson*, 1851. Trans. Micr. Soc., vol. iii, p. 115, pl. 17, fig. 8; pl. 18, figs. 9—14.

ORBITOLITES COMPLANATUS, *Jones*, 1854. Morris's Cat. Brit. Foss., 2nd edit., p. 39.

— COMPLANATA, *Carpenter*, 1856. Phil. Trans., vol. cxlvi, p. 181, pls. 4—9; 1862, Introd. Foram., p. 105, pl. 9.

— — *Parker and Jones*, 1860. Ann. N. H., 3rd ser., vol. v, p. 291, &c.

Characters.—Shell circular, discoidal, flat, sometimes slightly bi-concave. Chambers consisting of narrow concentric bands, subdivided into chamberlets, which alternate, after the pattern of the *Spiral of Archimedes* (Haughton); surface marked by furrows, indicating the margins of the chamberlets. Shell composed of one (simple type) or several (complex

type) layers of chambers. Pseudopodial orifices situated in depressions on the lateral face of the external annular chamber. In the simple type, consisting of a single row of pores, there is one pore in each depression; in the complex type several rows, roughly corresponding to the number of layers of chambers. Diameter, $\frac{1}{12}$ th inch to 1 inch.

As the variations from the typical form are so unimportant that subdivision is unnecessary, little need be added in respect to the species, not already given in the generic distinctions. Ehrenberg rightly referred his "*Sorites*" (a simple Orbitolite) to the *N. orbiculus*, of Forskål, whose description of it embraces also "*Amphisorus*" (complex in growth).

We have seen but one or two perfect specimens of *Orbitolites orbiculus* from the Crag (Sutton), and these have been imbedded in a hard matrix; but we have a few fragments separated from the rock. Our figure, Plate III, fig. 45, is taken from one of these fragments; and figures 46 and 47 illustrate the structure of the complex type, the one being a view of a portion of the edge of a specimen, showing the pseudopodial apertures; the other a vertical section, exhibiting the arrangement of the chambers, and their connection with each other.

The distribution of *Orbitolites* is almost confined to tropical latitudes, its range extending but little into the seas of the temperate zones. On the Australian shores, in the Indian Ocean, and in the Caribbean and Red Seas, it is, perhaps, most abundant. It exists in the Mediterranean. Fossil specimens are first found in the Maestricht Beds (*O. macropora*), and it reaches its maximum abundance in the *Calcaire grossier* of the Paris Basin. It is also found in the Bracklesham beds of Hampshire.

ALVEOLINA, sp.

We may notice, in passing, the occurrence of one or two somewhat obscure specimens of *Alveolina* that we found in the Bryozoan Crag of Sudbourne. They have been unfortunately lost. These were so worn and devoid of character as scarcely to admit of specific determination; their presence, however, is of interest in connection with that of some other species which may have been derived from earlier Tertiary formations.

FAMILY—LITUOLIDA, *Carpenter*.*Genus*—TROCHAMMINA, *Parker and Jones*.WEBBINA, *D'Orb.* (in part).ROTALINA, *Williamson* (in part).TROCHAMMINA, *Parker and Jones, Reuss, Carpenter, and Brady*.AMMODISCUS, *Reuss* (!).

General characters.—Shell free or attached, very variable in form, consisting of one or many chambers. Texture arenaceous, the sandy constituents being held together by an ochreous cement, and not projecting above the surface, which is smooth. Polythalamous varieties have no proper septa; but the division into chambers is effected by constriction or infolding of the primary shell-wall.

The genus *Trochammina* differs from *Lituola* and the other arenaceous genera in the fact that, although its walls are chiefly built up of sand-grains, the particles are so incorporated in the calcareous cement that the surface of the shell is usually quite smooth. The solitary specimen, on the strength of which we accept *Trochammina* (*Webbina*) *irregularis* as a Crag species, is perhaps the most obscure form of the genus, and one which may be readily overlooked. It consists of a minute, subconical, tent-like, circular disc, growing parasitically on a flat bit of shell, and presenting no character to arrest the attention. Indeed, it is only by the knowledge gained in the examination of a large number of specimens that we are enabled to recognise its affinities, or even to satisfy ourselves of its belonging to the Foraminifera.

The simplest forms of *Trochammina* belong to a species (*T.* [*Webbina*] *irregularis*, *D'Orb.*) of which we have four varieties; and, since it is useful to have a "subgeneric" name distinguishing them from *Trochammina* proper (as is the case with so many other Foraminiferal groups), we have proposed ('Phil. Trans.,' 1865, p. 435) to retain *D'Orbigny's* term "*Webbina*," applied by him to one of them, although first used for a few-chambered, uniserial, curved form of *Nubecularia rugosa* ('Foram. Canaries,' p. 126, pl. 1, figs. 16—18; and 'For. Foss. Vien.,' p. 74, pl. 21, figs. 11, 12).

1. *Webbina irregularis*, *D'Orb.*, is adherent, moniliform, with more or less oval chambers, and varies in the relative length of its stoloniferous connecting tubes, in the number of its chambers, and in the straightness or curvature of their line of growth. Sometimes the stolons bifurcate, giving rise to a branching arrangement of a few chambers, common in strata of Cretaceous age, the Oxford Clay, &c. ('Quart. Journ. Geol. Soc.,' 1860, vol. xvi, p. 304; 'Carpenter's Introd. Foram.,' 1862, p. 141, pl. 11, figs. 8, 9).

2. *Webbina irregularis alternans*, *P. & J.*, is adherent, and has the stolons issuing

from the chambers alternately from their sides as well as from their fronts, giving the shell a loosely Textularian character; its chambers are usually somewhat pyriform. In deep Mediterranean soundings; and in the Chalkmarl ('Q. J. G. S.,' *loc. cit.*; Carpenter's 'Introd.,' *loc. cit.*, fig. 10).

3. *Webbina irregularis clavata*, P. & J., is also a fixed form, and consists frequently of a single pyriform chamber, tubular at one end, and bearing a slightly margined and semioval aperture at the other. The tubular portion frequently gives off another tube and chamber, thus almost identifying itself with the bifurcating forms of *W. irregularis* proper. Common at great depths in the Mediterranean and South Atlantic ('Q. J. G. S.,' *loc. cit.*; Carpenter's 'Introd.,' *l. c.*, figs. 6, 7).

4. *Webbina irregularis hemisphærica*, nov. The specimen from the Crag described further on, barely separable from the last.

Trochammina (proper) is typified by *Tr. squamata*, P. & J., comprising five known varieties, which have spiral shells, more or less rotaliform in their growth.

1. The simpler of these forms, such as *Tr. squamata incerta* (*Operculina incerta*, D'Orb., 'For. Cuba,' p. 49, pl. 6, figs. 16, 17; *Spirillina arenacea*, Williamson, 'Monog. Brit. For.,' p. 93, pl. 7, fig. 203; *Ammodiscus* (?), Reuss, 'Sitz. Akad. Wien.,' 1861, vol. xlv, p. 365), consist of a long, spiral, undivided chamber, having the shape of the clear, perforated, discoidal *Spirillina vivipara*, Ehrenb., and of the white opaque *Cornuspira foliacea*, Phil. Living in the Atlantic; common at great depths in the Mediterranean. Fossil in the Gault, Lower Oolite, &c. (See 'Q. J. G. S.,' *l. c.*; and Carpenter's 'Introd.,' *l. c.*, fig. 2).

2. *Tr. squamata charoides*, P. & J., is a similar undivided tubular chamber vertically spiral, presenting a resemblance to the fruit of the *Chara*. Common in deep water; Mediterranean, Red Sea, and South Atlantic ('Q. J. G. S.,' *l. c.*; and Carpenter's 'Introd.,' *l. c.*, fig. 3).

3. The third variety, *Tr. squamata gordialis*, P. and J. ('Q. J. G. S.,' *l. c.*; Carpenter's 'Introd. For.,' *l. c.*, fig. 4; Parker and Jones, 'Phil. Trans.,' vol. clv, p. 408, pl. 15, fig. 32), has more than one chamber, the shell in the early stage being formed of a few spirally arranged, but variable chambers; and at a later period they are moulded on an undivided vermiform sarcode, sometimes slightly constricted at intervals, and either discoidal or irregularly elevated; often passing at nearly right angles over the primary disc, or forming sudden loops and twistings. It lives in the Red, Indian, and Arctic Seas. The "Permian" *Serpula pusilla* of Schlotheim (*Spirillina pusilla*, Jones; *Miliola* (?) *pusilla*, Kirby), and some forms of the Cretaceous (?) *Trochammina proteus* of Karrer, belong to the same. Indeed, the excellent figures of *T. proteus*, in Dr. Karrer's paper on the Old Vienna Sandstone, 'Sitz. Akad. Wien. Math.-Nat. Cl.,' vol. lii, 1 Abth., 1865, pl. 1, figs. 1—8, comprise modifications of *Tr. gordialis* (figs. 1, 2, 3, 8), *charoides* (fig. 4), *squamata* (fig. 6), and irregular *squamata*, or passage from lobulate *gordialis* to *squamata* (fig. 5). We may also remark that fig. 10 (named *Cornuspira Hoernesii*) is probably *Trochammina incerta*.

4. *Tr. squamata* (proper), P. and J., has the shell divided throughout into lunate and flattened chambers, several in a whorl, and regularly increasing with the progress of growth. It much resembles those flatter varieties of *Discorbina turbo* which are intermediate to *D. globularis* and *D. rosacea*, and it may easily be confounded with little, conical, scale-like varieties of *Valvulina triangularis*, but the latter never have more than three chambers in a whorl, and are more coarsely sandy. *Tr. squamata* lives both in the Arctic Ocean and the Mediterranean at considerable depths ('Quart. Journ. Geol. Soc.,' vol. xvi, p. 305; Carpenter's 'Introd.,' l. c., fig. 1; Parker and Jones, 'Phil. Trans.,' vol. clv, p. 407, pl. 15, figs. 30, 31. It is well figured by Karrer (see above) from a fossil specimen).

5. *T. squamata inflata*, Montagu, sp., rostraliform, consisting of several (20) ventricose chambers, increasing rapidly in size, few (5) showing beneath. (See Williamson's 'Monograph Rec. Brit. For.,' 1857, p. 50, pl. 4, figs. 93, 94; 'Ann. N. H.,' 3rd ser., vol. iv, p. 347; and Carpenter's 'Introd. Foram.,' p. 141, pl. 11, fig. 5.) Common in the brackish estuarine pools on our north-east shore (see Brady, 'Nat. His. Trans. Northumberland and Durham,' vol. i, p. 95); and found very rarely in deeper water on the British Coast; also living on the shores of the Mediterranean, and in the depths of the Arctic and South Atlantic Oceans. It also occurs in a sub-fossil condition in the clay underlying the peat of the Lincolnshire and Cambridgeshire fens.

Subgenus—WEBBINA, D'Orbigny.

General characters.—Shell adherent, comprising one or more pyriform, oval, or round chambers, subarenaceous, smooth, dirty white, or of a deep rusty colour; and, when numerous, arranged in a single, irregular, moniliform line, often branched.

1. WEBBINA HEMISPHERICA, nov. Plate IV, fig. 5.

Characters.—Small, circular, subconical, monothalamous, like a low bell-tent, parasitic; recognisable only by its smooth but sandy shell, and general resemblance to the common forms of *Webbina irregularis*.

Diameter, $\frac{1}{50}$ inch.

One specimen only of this little parasitical *Trochammina* (*Webbina*) *irregularis*, var. *hemisphærica*, occurs among the Foraminifera from Sutton.

SUB-ORDER—*PERFORATA*.

FAMILY—LAGENIDA.

Genus—LAGENA, *Walker and Jacob*.¹SERPULA (LAGENA), *Walker and Jacob*.VERMICULUM, *Montagu*.SERPULA, *Maton and Rackett, Pennant, Turton*.LAGENULA, *De Montfort, Fleming, Macgillivray, Thorpe*.OOLINA, *D'Orbigny, Reuss, Bronn, Egger, Terquem, Bornemann, Costa*.MILIOLA, CENCHRIDIUM, *Ehrenberg*.ENTOSOLENIA, *Ehrenberg, Williamson*.OVULINA, *Ehrenberg, Bornemann, Seguenza*.APIOPTERINA (parte), *Zborezewski*.LAGENA, *Williamson, Morris, Parker and Jones, Carpenter, Reuss, Brady*.FISSURINA, *Reuss, Bronn, Egger, Seguenza*.AMPHORINA, *D'Orbigny, Costa, Seguenza*.AMYGDALINA, PHIALINA, *Costa, Seguenza*.TETRAGONULINA, TRIGONULINA, OBLIQUINA, *Seguenza*.

General characters.—Shell one-chambered, free, oval, oblong, or fusiform, and subject

¹ We append to the generic name *Lagena*, and to a number of the specific forms, the initials W. & J. (*Walker and Jacob*), believing this to be the nearest approach to correctness we can make, though some authors have, with almost equal reason, assigned the same species to the authority of Walker and Boys, and others to Walker. The 'Testacea Minuta Rariora' is stated on its title-page to relate to "minute and rare shells lately discovered in the sand of the sea-shore, near Sandwich, by William Boys, F.S.A., considerably augmented, and all their figures drawn by George Walker," the latter of whom is spoken of in the same page as the author; and his name also appears alone in the dedication. Prof. Williamson, in his 'Monograph,' has given his reasons why the species may be regarded as *Walker's*; and in the 'Annals Nat. Hist.' for November, 1859, Mr. Jacob's title to their authorship is shown.

We have, however, in our possession a copy of the work, which has evidently been the property of a naturalist, having the following note written on the fly-leaf, in ink apparently nearly as old as the book itself—"the scientific descriptions in this work were written by Dr. Solander."

The figures from the 'Testacea Minuta' were reprinted and further augmented in Kanmacher's edition of Adams's 'Essays on the Microscope' (1789), and the original work is therein stated to have been written by Mr. Walker and Mr. Boys, assisted by Edward Jacob, Esq., F.S.A.

We know that Dr. Solander wrote the scientific descriptions of Ellis's work on the 'Zoophytes,' and, singularly enough, Mr. Ellis's name appears in connection with some allied microscopical organisms on the following page in the 'Essays,' a fact which suggests associations increasing the probability of the manuscript note alluded to.

If Mr. Boys collected, Mr. Walker augmented and figured, Mr. Jacob assisted, Dr. Solander described, and Mr. Kanmacher further elaborated, added to, and republished, it is not easy to decide whose initials should be appended to such of their specific names as take precedence; at least, we see no reason to change the practice we have hitherto adopted in assigning them to "Walker and Jacob."

to a very variable amount of lateral compression, either on two, three, or four sides. Aperture usually single; in the exceptional distomatous forms the two orifices are at opposite ends of the shell. Shell-wall perforated by numerous very minute foramina.¹ Texture, hyaline.

For our views of the relationship of *Lagena*, in its manifold variations, see the 'Philos. Transact.,' 1865, vol. clv, p. 345, &c. The accompanying table of the distribution of fossil *Lagenæ* will be of interest to geologists, who can also refer to a general list of fossil and recent *Lagenæ*, by Prof. Reuss, in the 'Sitzungsb. Akad. Wiss. Wien.,' 1862, vol. xlvi, p. 317.

In our table we have arranged the *Lagenæ* according to our scheme of the prominent forms, as indicated in 'Phil. Trans.,' *loc. cit.*, p. 343, introducing some that do not occur fossil, to make the series complete; and we have introduced into the table materials from the works of Reuss, Seguenza, and others, having made their nomenclature conformable with ours.

¹ The keel of the compressed *Lagenæ*, and the marginal ribs of the angular varieties, are formed of "the supplementary skeleton," or secondary shell, containing what has been termed "the canal-system." Occasionally, as in *Lagena tubifero-squamosa*, P. & J. ('Phil. Trans.,' 1865, p. 420), the whole surface is coated with this extra shell-growth. The circular cavities, or "lacunæ," in the keel of *L. ornata*, shown in Williamson's 'Monograph,' pl. 1, fig. 24, are really continuous with the minute pseudopodial perforations of the shell-wall, usually by delicate bundles of tubuli; and they communicate with the exterior by a coarse pseudopodial tube.

TABLE SHOWING THE DISTRIBUTION OF THE CHIEF

vl. Very large. *l.* Large. *m.* Middle-sized. *s.* Small. *VR.* Very rare. *R.* Rare.

GENUS, SPECIES, AND VARIETIES.		Upper Chalk, Maestrich.	Eocene, Grignon.	Eocene?, Septarienthon, Berlin. (Bornemann and Reuss.)	Eocene?, Baljik, Bulgaria.	Miocene, Vienna. (D'Orb., Czyzek, and Reuss.)	Miocene, Lower Bavaria. (Egger.)
		1.	2.	3.	4.	5.	6.
1.	<i>Lagena globosa</i> , Montagu	<i>l</i> C	<i>vl</i> VC	*	...	...	*
2.	— <i>lævis</i> , Montagu .....	...	<i>l</i> VC	*	...	...	*
3.	— <i>crenata</i> , Parker and Jones .....	...	...	...	...	*	...
4.	— <i>clavata</i> , D'Orbigny .....	...	...	...	...	...	...
5.	— <i>semistriata</i> , Williamson .....	...	<i>m</i> R	*	<i>m</i> R	...	*
6.	— <i>striata</i> , D'Orb. ....	...	<i>m</i> RR	*	...	*	*
7.	— <i>sulcata</i> , Walker and Jacob	<i>vl</i> RC	<i>l</i> RC	*	...	...	*
8.	— <i>striato-punctata</i> , P. & J. ....	...	<i>s</i> VC	...	...	...	...
9.	— <i>tetragona</i> , P. & J. ....	...	<i>vs</i> C	...	...	...	...
10.	— <i>acuticosta</i> , Reuss .....	*	...	...	...	...	*
11.	— <i>melo</i> , D'Orb. ....	...	...	*	...	...	...
12.	— <i>hexagona</i> , Williamson (favosa, Reuss) .....	...	...	...	...	...	...
13.	— <i>squamosa</i> , Montagu .....	...	...	...	...	...	...
14.	— <i>squamoso-tubifera</i> , P. & J. ....	...	<i>vl</i> VC	...	...	...	...
15.	— <i>hispida</i> , Reuss .....	...	...	*	...	...	...
16.	— <i>aspera</i> , Reuss .....	*	...	...	...	...	...
17.	— <i>marginata</i> , Montagu .....	...	<i>l</i> VC	*	<i>m</i> R	*	*
18.	— <i>ornata</i> , Williamson .....	...	...	...	...	...	...
19.	— <i>radiato-marginata</i> , P. & J. ....	...	...	...	...	...	...
20.	— <i>squamoso-marginata</i> , P. & J. ....	...	<i>m</i> R	...	...	...	...
21.	— <i>trigono-marginata</i> , P. & J. ....	...	<i>s</i> VR	...	...	...	...
22.	— <i>apiculata</i> , ¹ Reuss .....	*	...	*	...	...	...
23.	— <i>gracillima</i> , Seguenza ² .....	...	...	...	...	...	...
24.	— <i>caudata</i> , D'Orb. ....	...	<i>s</i> C	...	...	...	...
25.	— <i>distoma</i> , P. & J. ....	...	...	...	...	...	...
26.	— <i>distomo-aculeata</i> , P. & J. ....	...	<i>s</i> VR	...	...	...	...
27.	— <i>distomo-margaritifera</i> , P. & J. ....	...	...	...	...	...	...
		1.	2.	3.	4.	5.	6.

¹ Found also in the Gault.—Reuss.

² We must also refer to Prof. Seguenza's 'Descrizione dei Foraminiferi Monotalamici,' &c., for some *prima*, and his *Trigonulinae*, all from the Miocene marls of Messina. *Lagena trigono-marginata*, P. & J.,

FORMS OF LAGENA IN FOSSIL DEPOSITS.

RR. Rather rare. RC. Rather common. C. Common. VC. Very common.

Miocene, Bordeaux.	Miocene, Malaga.	Miocene, San Domingo.	Pliocene ?, Ototara, New Zealand.	Pliocene, Sienna.	Miocene, Sicily. (Seguenza.)	Pliocene, Antwerp Crag. (Reuss.)	Pliocene, Crag, Sutton.	Crag, Suffolk. (Mixed gatherings.)	Crag, Norwich.	Crag, Bridlington.	Pleistocene, Canada. (Dr. Dawson.)	Living.	
7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	
l VC	*	...	s R	l C	...	...	*	*	1.
l VC	*	*	s R	...	...	...	...	*	2.
m R	m RC	...	...	...	...	...	...	...	...	...	...	*	3.
m RR	*	*	*	4.
l VC	*	*	s VR	...	...	...	...	*	5.
l VC	s R	*	*	...	m VR	...	...	...	*	6.
m VC	l C	...	*	*	vl VC	l VC	l C	m R	*	*	7.
...	*	8.
...	9.
...	*	m R	...	...	*	*	10.
...	*	11.
m R	l RR	...	*	*	...	s R	...	s R	*	*	12.
...	13.
...	*	14.
...	*	15.
m VC	s R	...	...	s R	*	...	s VR	l C	m VR	...	...	*	16.
...	*	...	m VR	...	...	...	...	*	17.
m RC	*	18.
...	...	s VR	...	...	...	...	...	...	...	...	...	*	19.
...	*	*	20.
...	*	...	s VR	...	...	...	...	*	21.
m R	*	...	vl R	...	...	...	...	*	22.
...	m C	...	*	...	s VR	...	...	...	*	*	23.
...	*	24.
...	25.
...	26.
...	*	27.
7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	

other well-marked modifications of *Lagena*; such as his *Fissurina dentata*, *F. spinigera*, *Tetragonulina* is the same as *Trigonulina globosa*, Seg.

1. *LAGENA GLOBOSA*, *Montagu*, Pl. I, fig. 32.

Serpula (*Lagena*) *lævis globosa*, *Walker and Jacob*, 1784. *Test. Min.*, p. 3, pl. 1, fig. 8.

VERMICULUM GLOBOSUM, *Montagu*, 1803. *Test. Brit.*, p. 523.

SERPULA GLOBOSA, *Maton and Rackett*, 1807. *Trans. Linn. Soc.*, vol. viii, p. 247.

— — *Turton*, 1819. *Conch. Dict.*, p. 157.

— — *Fleming*, 1828. *Brit. Anim.*, p. 235.

OOLINA INORNATA, *D'Orb.*, 1839. *Amer. Mérid.*, p. 21, pl. 5, fig. 13.

ENTOSOLENIA GLOBOSA, *Williamson*, 1848. *Ann. Nat. Hist.*, 2nd ser., vol. i, p. 16, pl. 2, figs. 13, 14.

— *LINEATA*, *Id.* *Ib.*, p. 18, pl. 2, fig. 18.

OOLINA SIMPLEX, *Reuss*, 1851. *Haiding. Naturw. Abhand.*, vol. iv, p. 22, pl. 1, fig. 2.

CENCHRIDIUM OLIVA, *Ehrenberg*, 1854. *Mikrogeologie*, part 2, p. 22, pl. 24, figs. 3, 4.

MILIOLA SPHÆROIDEA, *Id.* *Ib.*, pl. 23, fig. 1.

— *OVUM*, *Id.* *Ib.*, pl. 23, fig. 2; pl. 27, fig. 1; pl. 29, fig. 45.

FISSURINA OBTUSA, *Egger*, 1857. *For. Mioc. Nied.-Bay.*, p. 8, pl. 1, figs. 16—19.

ENTOSOLENIA GLOBOSA, *Parker and Jones*, 1857. *Ib.*, vol. xix, pl. 11, figs. 25—29.

— — (typica), *Will.*, 1858. *Rec. For. Br.*, p. 8, pl. 1, figs. 15, 16.

LAGENA (ENTOSOLENIA) GLOBOSA, *P. and J.*, 1859. *Ann. N. Hist.*, 3rd ser., vol. iv, p. 341, &c.

FISSURINA SOLIDA, *Seguenza*, 1862. *Foram. Monotal. Mioc. Messin.*, p. 56, pl. 1, fig. 42.

— *RUGOSULA*, *Id.* *Ib.*, pl. 1, fig. 43.

LAGENA GLOBOSA, *Reuss*, 1863. *Sitz. Akad. Wiss. Wien.*, vol. xlvi, p. 318, pl. 1, figs. 1—3.

— *INORNATA*, *Id.* *Ib.*, p. 32, pl. 1, fig. 12.

— *GLOBOSA*, *Brady*, 1864. *Trans. Linn. Soc.*, vol. xxiv, p. 472.

— *SULCATA*, var. (*ENTOSOLENIA*) *GLOBOSA*, *P. and J.*, 1865. *Phil. Trans.*, vol. clv, p. 348, pl. 13, fig. 37; pl. 16, fig. 10.

Characters.—Shell ovato-globose, sometimes projecting slightly at the apex; smooth, and without surface-marking. Tube Entosolenian. Walls, thin and hyaline. Length $\frac{1}{100}$ th inch or less to $\frac{1}{30}$ th inch.

This is the simplest and, perhaps, the smallest of the Entosolenian *Lagenæ*, and holds an intermediate position between the smooth flask-shaped *E. lævis* and the swollen varieties of *L. marginata*. It was first figured and described by Walker and Boys, but not named by Walker and Jacob in Kaumacher's edition of Adams's 'Essays on the Microscope,' where the specific names given by Walker and Jacob are recorded. It was named by Montagu, 'Test. Brit.,' p. 523.

Lagena globosa is one of the commonest varieties of the genus. On all parts of the British coast it may be met with in dredged and littoral sands. At the Hunde Islands it has been found in material dredged at from thirty to seventy fathoms. In Baffin's Bay, lat. 75° 10' N., long. 60° 12' W., it seems to be rare, but is of large size—a curious

fact, corresponding to the occurrence of equally large individuals of this variety at very great depths (1080 fathoms) in the tropical Atlantic (lat. $2^{\circ} 20' N.$, long. $28^{\circ} 44' W.$).

Professor Reuss has it fossil from the Chalk of Maestricht and of Lemberg, from the Oligocene Septarium-clay of Pietzpuhl, the Salt-clay of Wieliczka, and the Crag of Antwerp ('Monogr. Lagen.', p. 318); and in other Tertiary deposits it is not uncommon.

The Crag specimens are generally above the average size; and the number of examples in the *Cardita senilis* bed and the bed with *Cyprina Islandica* is considerable.

2. LAGENA LÆVIS, *Montagu*. Plate I, fig. 28.

Serpula (*Lagena*) *lævis ovalis*, *Walker and Jacob*, 1784. Test. Minut., p. 3, pl. 1, fig. 9.

VERMICULUM LÆVE, *Montagu*, 1803. Test. Brit., p. 524.

SERPULA LÆVIS, *Maton and Rackett*, 1807. Trans. Linn. Soc., vol. viii, p. 247.

— — *Turton*, 1819. Conch. Dict., p. 157.

LAGENULA — *Fleming*, 1828. Brit. Anim., p. 235.

— — *Macgillivray*, 1843. Moll. Anim. Aberd., p. 38.

— — *Thorpe*, 1844. Brit. Mar. Conch., p. 234.

LAGENA — *Williamson*, 1848. Ann. Nat. Hist., 2nd ser., vol. i, p. 12, pl. 1, figs. 1, 2.

CENCHRIDIUM DACTYLUM, *Ehrenb.*, 1854. Mikrogeologie, part 2, p. 22, pl. 24, figs. 1, 2.

MILIOLA LÆVIS, *Id.* Ib., p. 23, pl. 32, fig. 2 *a* (not pl. 26, fig. 2).

OVULINA CLAVA, *Id.* Ib., fig. 2 *b*.

PHIALINA OVIFORMIS, *Costa*, 1854—1856. Paleont. Napoli, pl. 11, fig. 9.

AMYGDALINA CALABRA, *Id.* Ib., p. 124, figs. 6, 8.

LAGENA LÆVIS, *Parker and Jones*, 1857. Ann. Nat. Hist., 2nd ser., vol. xix, p. 279, pl. 11, figs. 22—24.

— VULGARIS, *Will.*, 1858. Rec. For. Br., p. 4, pl. 1, figs. 5, 5 *a*.

MILIOLA STYLIGERA, *Ehrenb.*, 1858. Mikrogeologie, part 2, p. 23, pl. 31, fig. 6.

LAGENA SIPHONIFERA, *Reuss*, 1858. Zeitschr. Deutsch. Geol. Ges., vol. x, p. 433.

— SULCATA, var. LÆVIS, *P. and J.*, 1859. Ann. N. Hist., 3rd ser., vol. iv, p. 341, &c.

— VULGARIS *Reuss*, 1862. Sitz. Akad. Wiss., vol. xlvi, p. 321, pl. 1, fig. 15; pl. 2, figs. 16, 17.

PHIALINA PROPINQUA, *Seguenza*, 1862. For. Mon. Mioc. Messin., p. 43, pl. 1, fig. 13.

— OVATA, *Id.* Ib., p. 44, pl. 1, fig. 14.

— LONGIROSTRIS, *Id.* Ib., p. 44, pl. 1, fig. 15.

— AFFINIS, *Id.* Ib., p. 44, pl. 1, fig. 16.

— CLAVATA, *Id.* Ib., p. 45, pl. 1, fig. 17.

LAGENA LÆVIS, *Brady*, 1864. Trans. Linn. Soc., vol. xxiv, p. 472.

— SULCATA, var. LÆVIS, *P. and J.*, 1865. Phil. Trans., vol. clv, p. 349, pl. 13, fig. 22; and pl. xvi, fig. 9 *a*.

Characters.—Shell flask-shaped, with elongated neck; smooth and destitute of ornament. Neck frequently thickened at the mouth, so as to form a sort of lip. Colour white; very transparent. Length $\frac{1}{80}$ th to $\frac{1}{30}$ th.

The distribution of the common, smooth, flask-shaped *Lagenæ* is world-wide; they are often found at considerable depths, but shallow water appears to be their favorite habitat. In the fossil state this smooth variety is very abundant in the Post-pliocene clays of Lincolnshire and Cambridgeshire, and in the Grignon beds (Eocene); it occurs also in the Vienna Tertiaries, and in the Crag of Antwerp and the Septarium-clay of Pietzpuhl (Reuss); in the Tertiary beds of Taranto (Costa), and in the Miocene clay of Messina (Seguenza).

The Crag specimens in Mr. Wood's Sutton collection are few in number, and small.

3. LAGENA SEMISTRIATA, *Williamson*. Plate IV, fig. 6.

- OOLINA STRIATICOLLIS, *D'Orb.*, 1839. For. Amér. Mérid., p. 21, pl. 5, fig. 14.
LAGENA STRIATA, var. β , SEMISTRIATA, *Williamson*, 1848. Ann. Mag. Nat. Hist., 2nd ser., vol. i, p. 14, pl. 1, figs. 9, 10.
OVULINA LACRYMA, O. TENUIS, *Bornemann*, 1855. Zeitsch. Deutsch. Geol. Ges., vol. vii, p. 307, pl. 12, figs. 2, 3, 3*.
OOLINA PUNCTATA, O. STRIATULA, *Egger*, 1857. Foram. Mioc. Nied.-Bay., p. 6, pl. 1, figs. 1—8.
LAGENA VULGARIS, var. SEMISTRIATA, *Williamson*, 1858. Rec. For. Br., p. 6, pl. 1, fig. 9.
— — var. PERLUCIDA, *Id.*, 1858. Ib., p. 5, pl. 1, figs. 7, 8.
— — var. SEMISTRIATA, *Reuss*, 1862. Sitz. Akad., vol. xvi, p. 322, pl. 2, figs. 18—21.
— TENUIS (parte), *Id.* Ib., p. 325, pl. 3, figs. 34—39.
— STRIATA (parte), *Id.* Ib., p. 327, pl. 3, fig. 45.
PHIALINA LONGISSIMA, *Seguenza*, 1862. For. Mon. Mioc. Messin., p. 45, pl. 1, fig. 18.
— SEMICOSTATA, *Id.* Ib., fig. 19.
LAGENA SULCATA, var. SEMISTRIATA, *Parker and Jones*, 1862. In Append. Carpenter's Introd., p. 309.
— SEMISTRIATA, *Brady*, 1864. Trans. Lin. Soc., vol. xxiv, p. 472.
— SULCATA, var. SEMISTRIATA, *P. and J.*, 1865. Phil. Trans., vol. clv, p. 350, pl. 13, fig. 23.

Characters.—Shell flask-shaped, usually having the neck longer in proportion to the body than in the other varieties, having striæ and riblets extending from the base of the shell upwards for a short distance on the sides. Colour white; very transparent. Length $\frac{1}{80}$ th to $\frac{1}{30}$ th inch.

This is not an uncommon subvarietal form where *Lagenæ* prevail; but there is too little that is distinctive in its differentiation from elongated specimens of the typical *L. sulcata* to lay down any very definite scheme of its distribution. As Professor Williamson remarks, the costæ may terminate either in the lower, middle, or upper third of the shell; and though in the first or even the second case it would be easily recognised, it is obvious that in many individuals with longer ribs other characters, such as the length

of neck and general contour of the shell, would have to be chiefly considered; and these, as we well know, are extremely variable. D'Orbigny's figure of *L. striatocollis* represents a poorly defined specimen of this subtype.

It is very common to meet with *Lagenæ*, both recent and fossil, taking on striæ and riblets to greater or less extent, as in this instance. Reuss figures finely striated specimens from the Crag of Antwerp in his paper on the *Lagenidæ*, 'Sitzungsb. Wien. Akad.,' vol. xlvi, pl. 2, figs. 18—21. Dr. Wallich, in his memoir on the North-Atlantic sea-bed, figures *L. semistriata* (pl. 5, fig. 17); and D'Orbigny's *Oolina striaticollis* (Falkland Isles) belongs to the same variety. It is a common form on our British coast. Egger's *Oolina striatula* offers an interesting passage-form (especially his fig. 6) between *L. semistriata* and *L. crenata*, P. and J.

Only a single broken specimen has occurred to us in our examination of the Crag deposits, and this is from Sutton.

4. LAGENA STRIATA, D'Orbigny (not of Montagu and Williamson). Plate I, figs. 38—40.

OOLINA STRIATA, D'Orb., 1839. Foram. Amér. Mérid., p. 21, pl. 5, fig. 12.

— HAIDINGERI, Czjzek, 1847. Haiding. Nat. Abhandl., vol. ii, p. 138, pl. 12, figs. 1, 2.

LAGENA SUBSTRIATA, Williamson, 1848. Ann. N. H., 2nd ser., vol. i, p. 15, pl. 2, fig. 12.

OVULINA SICULA, Ehrenb., 1854. Mikrogeologie, part 2, p. 23, pl. 26, fig. 1.

LAGENA VULGARIS, var. GRACILIS, Will., 1858. Rec. For. Brit., p. 7, pl. 1, figs. 12, 13.

— — var. SUBSTRIATA, Id. Ib., p. 7, pl. 1, fig. 14.

— GRACILICOSTA, Reuss, 1858. Zeitsch. Deut. Geol. Ges., vol. x, p. 434; 1862, Sitz. Akad. Wien., vol. xlvi, p. 327, pl. 3, figs. 42, 43.

— STRIATA (parte), Id., 1862. Sitz. Akad., vol. xlvi, p. 327, pl. 3, fig. 44; pl. 4, figs. 46, 47.

OVULINA STRIATA, Seguenza, 1862. Foram. Monot. Messina, p. 40, pl. 1, figs. 6, 7.

PHIALINA HAIDINGERI, Id. Ib., p. 46, pl. 1, fig. 20.

— TENUISTRIATA, PH. GEMELLARI, PH. CYLINDRACEA, Id. Ib., figs. 21, 23, 24.

LAGENA — Stache, 1865. Novara-Exped., Geol. Theil., vol. i, part 2, p. 184, pl. 22, fig. 4 (like our fig. 40, Pl. I).

Characters.—Flask-shaped *Lagenæ* of variable dimensions, ornamented with delicate longitudinal and sometimes spiral striæ and riblets, come under the denomination of *L. striata*. (See the scheme of *Lagenæ*, 'Phil. Trans.,' 1865, vol. clv, p. 384.) Out of this, however, as also out of the other groups, we separate the caudate or apiculate forms, leading towards the double-mouthed or distomatous, perforate, cylindrical *Lagenæ*, with which they make another artificial division.

L. striata accompanies the more common and strongly grown *Lagenæ* all over the world, and have existed with them in Tertiary times. We have a few specimens from the Crag of Sutton and of Sudbourne.

5. *LAGENA SULCATA*, *Walker and Jacob*. Plate I, figs. 41—43.

- Serpula* (*Lagena*) *striata sulcata rotundata*, *Walker and Jacob*, 1784. *Test. Min.*, p. 2, pl. 1, fig. 6.
- SERPULA* (*LAGENA*) *SULCATA*, *Id.*, 1798. In *Adams's Essays Microsc.* (*Kanmacher*), p. 634, pl. 14, fig. 5.
- SERPULA LAGENA*, *Turton*, 1802. *Syst. Nat.*, vol. iv, p. 609.
- VERMICULUM STRIATUM*, *Montagu*, 1803. *Test. Brit.*, part ii, p. 523.
- *PERLUCIDUM*, *Id.* *Ib.*, p. 525, pl. 14, fig. 3.
- LAGENULA STRIATA*, *L. PERLUCIDA*, *Fleming*, 1828. *Brit. Anim.*, pp. 234, 235.
- OOLINA VILLARDEBOANA*, *D'Orb.*, 1839. *For. Amér. Mérid.*, p. 5, pl. 5, figs. 4, 5.
- *ISABELLA*, *Id.* *Ib.*, p. 20, pl. 5, figs. 7, 8.
- *RARICOSTA*, *Id.* *Ib.*, p. 20, pl. 5, figs. 10, 11.
- LAGENA STRIATA*, *Williamson*, 1848. *Ann. N. Hist.*, 2nd ser., vol. i, p. 13, pl. 1, figs. 6 and 8.
- — *var. a, INTERRUPTA*, *Id.* *Ib.*, fig. 7.
- — *var. γ, PERLUCIDA*, *Id.* *Ib.*, fig. 11.
- MILIOLA STRIATA*, *Ehrenb.*, 1854. *Mikrogeol.*, part 2, p. 22, pl. 24, fig. 5; pl. 32, fig. 1.
- OVULINA ELEGANTISSIMA*, *Bornemann*, 1855. *Zeits. Deut. Geol. Ges.*, vol. vii, p. 315, pl. 12, fig. 1.
- ENTOSOLENIA GLOBOSA*, *var. STRIATA*, *Parker and Jones*, 1857. *Ann. Nat. Hist.*, 2nd ser., vol. xix, p. 278, pl. 11, fig. 27.
- LAGENA VULGARIS*, *var. PERLUCIDA*, *Williamson*, 1858. *Rec. For. Brit.*, p. 5, pl. 1, fig. 8.
- — *var. STRIATA*, *Id.* *Ib.*, p. 6, pl. 1, fig. 10.
- — *var. INTERRUPTA*, *Id.* *Ib.*, p. 7, pl. 1, fig. 11.
- ENTOSOLENIA COSTATA*, *Id.* *Ib.*, p. 9, pl. 1, fig. 18.
- LAGENA SULCATA*, *Parker and Jones*, 1859. *Ann. N. H.*, 3rd ser., vol. iv, p. 341, &c.
- OVULINA SULCATA*, *Seguenza*, 1862. *Foram. Mon. Mioc. Messina*, p. 41, pl. 1, figs. 8—10.
- PHIALINA LAGENA*, *Id.* *Ib.*, p. 46, pl. 1, fig. 22.
- *EXIGUA*, *P. INCERTA*, *P. COSTATA*, *P. COSTÆ*, *P. REUSSIANA*, *Id.* *Ib.*, p. 47, 48, pl. 1, figs. 25—29.
- OBLIQUINA ACUTICOSTA*, *Id.* *Ib.*, p. 75, pl. 2, figs. 65—67.
- LAGENA FILICOSTA*, *Reuss*, 1863. *Sitz. Akad. Wien.*, vol. xlv, p. 328, figs. 50, 51.
- *VILLARDEBOANA*, *L. COSTATA*, *L. ISABELLA*, *L. AMPHORA*, *Id.* *Ib.*, p. 329, 330, pl. 4, figs. 53—57.
- *SULCATA*, *Brady*, 1864. *Trans. Linn. Soc.*, vol. xxiv, p. 472.
- — *P. and J.*, 1865. *Phil. Trans.*, vol. clv, p. 351, pl. 13, figs. 24, 28—32; and pl. 16, figs. 6, 7, 7 a.

Characters.—Shell subspherical, oval, or flask-shaped, having a surface-ornamentation of parallel costæ, more or less strongly marked, generally extending from one end of the shell to the other. Colour white to brownish. Length, $\frac{1}{30}$ th to $\frac{1}{70}$ th inch.

We regard this as the typical form of *Lagena*, for its variations lead, in one direction, into feebler forms, such as *L. semistriata*, *lævis*, and *globosa*; and on the other hand we have varieties with reticulated, hispid, and granular ornament; we have also compressed forms and elongate varieties, departing more or less widely from the middle type presented by the ovate and characteristically costate *Lagenæ*.

The chief variations from this central type depend upon alterations in the nature of surface-ornamentation, or the shape, length, and direction of the neck. We are fully convinced that there is no true specific division determinable from these characters, either among the costate group above indicated, or even in the much wider range of *Lagenæ* in general. The division of the genus into Ectosolenian (*Lagenæ*) and Entosolenian (*Entosolnia*) groups, adopted by Professor Williamson, in his Memoir on the *Lagenæ*, and in his Monograph, whilst it might afford us some general assistance in classifying a bulky list of varieties, seems only to lead into greater difficulties, for we find that the principal forms may be traced in series from the pear-shaped body, with the long, thick-lipped neck, through every gradation of shortening, and eventually of intussusception. But if the distinctions founded on contour be thus open to objection, still less dependence is to be placed on the shape of the aperture, for systematic purposes. There can be little doubt that the typical form of the aperture, if we may judge from the finest and most fully developed specimens, is very similar to that of the *Polymorphinæ* and *Nodosarinæ*, a circular orifice surrounded by radiating lines. The radiation is only to be observed in exceptional specimens; but the majority of the *Lagenæ* preserve the circular form of orifice. In the feebler varieties, especially those which have no neck, there is a tendency towards an oval form of orifice, and in the flattened specimens grouped as *L. marginata* the typical round mouth is represented by a mere slit. Professor Reuss has divided his family *Lagenida* into two genera, *Lagenæ* and *Fissurina*, on these peculiarities. It has been reserved for Professor Seguenza to carry subdivision to an extreme. He recognises no less than eight "genera" of *Lagenida*, namely, *Ovulina* (shell oval, aperture circular), *Phialina* (shell oval, aperture at the top of an elongated tube), *Amphorina* (shell fusiform, aperture circular), *Tetragonulina* (shell square and tubulated, aperture circular), *Fissurina* (shell compressed and equilateral, aperture in the form of a slit), *Amygdalina* (shell compressed and inequilateral, aperture slit-like), *Trigonulina* (shell triangular, aperture slit-like), and, lastly, *Obliquina* (shell twisted, aperture circular).

We need not say that with such a generic subdivision we have no agreement; and still less, if it were possible, with his list of new species—an example of hair-splitting to which we know of no parallel in systematic zoology. Of the 102 "new species" of *Lagenæ* described in his memoir, there may, perhaps, be four or five undescribed forms worthy of subvarietal names; the rest are ordinary specimens of well-known forms, long since described. If the system pursued by the Italian professor were to be followed, it would soon become necessary to describe and name every individual specimen.

As we have before stated, the situation of the general aperture in relation to the body of the shell is exceedingly open to variation, even in groups of specimens identical in their other characters. We find in rare examples, under similar limitations, another complicity in the classification, arising from the occurrence of an orifice at each end of the shell. This peculiar development may be traced through the "caudate" varieties of the various forms; and, as all the feeble *Lagenæ*, especially clear-shelled and slightly striated individuals, have

their mucronate or caudate representatives, so many of them are produced still further, and have shells of fusiform contour, with both ends open for the passage of the larger pseudopodia. Specimens of this sort have been repeatedly figured, but their structural peculiarity appears entirely to have escaped the notice of Continental rhizopodists. Seguenza's genus *Amphorina* seems, judging by his figures, to consist of subvarieties of *Lagena sulcata caudata* and *L. sulcata distoma*; and an analysis of them will be found at p. 45, with the remarks on a distomatous form we have from the Sutton Crag.

The typical *Lagena sulcata* has a world-wide distribution, accommodating itself to almost all climates and depths. The finest specimens are found at a depth of from 50 to 100 fathoms, but it is plentiful in the shallowest water, and has been found in soundings as deep as 2350 fathoms in the Atlantic.

Its distribution in time appears to have commenced with the Upper Chalk of Maestricht. It is found in many of the European Tertiaries.

In the Crag, *L. sulcata* is a common fossil. The specimens from Sutton are fine and well marked; those from the Cyprina-bed are large, but in the bed with *Cardita* and in the Upper Crag at Thorpe the examples are smaller.

6. LAGENA MELO, *D'Orbigny*. Plate I, fig. 35.

OOLINA MELO, *D'Orb.*, 1847. Foram. Amér. Mérid., p. 20, pl. 5, fig. 9.

ENTOSOLENIA SQUAMOSA, var. α , CATENULATA, *Williamson*, 1848, Ann. Nat. Hist., 2nd ser., vol. i, p. 19, pl. 2, fig. 20; 1858, Rec. For. Br., p. 13, pl. 1, fig. 31.

— — var. β , SCALARIFORMIS, *Id.* A. N. H., 2nd ser., vol. i, p. 19, pl. 2, figs. 21, 22.

— GLOBOSA, var. CATENULATA, *Parker and Jones*, 1857. *Ib.*, 2nd ser., vol. xix, p. 278, pl. 11, fig. 26.

OVULINA RETICULATA, *Seguenza*, 1862. Foram. Monotal. Miocen. Messin., p. 42, pl. 1, fig. 11.

LAGENA MELO, *P. and J.*, 1862. Append. Carpenter's Intro., p. 309.

— FOVEOLATA, *Reuss*, 1862. Sitz. Akad. Wien., vol. xlvi, p. 332, pl. 5, fig. 65.

— SCALARIFORMIS (parte), *Id.* *Ib.*, pl. 5, fig. 71.

— CATENULATA, *Id.* *Ib.*, pl. 6, figs. 75, 76.

— MELO, *Brady*, 1864. Trans. Linn. Soc., vol. xxiv, p. 472; 1865, Nat. Hist. Trans., North. and Durham, vol. i, p. 97.

— SULCATA, var. (ENTOSOLENIA) MELO, *P. and J.*, 1865. Phil. Trans., vol. clv, p. 354, pl. 13, figs. 33—36.

Characters.—Shell ovato-globose or pear-shaped, usually Entosolenian. Surface covered by reticulated ornament of longitudinal and transverse ridges, the transverse being frequently less freely developed than the longitudinal bars. Colour white or dirty white. Length $\frac{1}{100}$ th or less to $\frac{1}{50}$ th inch.

Lagena Melo may be looked upon as intermediate between *L. sulcata* and *L. squa-*

mosa. Many specimens show their connection with the former in having stout longitudinal ridges, with very slightly developed cross-bars; whilst others, with equally grown ornament, only want a zigzag inflection of the primary costæ to give them the characters of *L. squamosa*. We have suggested an artificial division of these closely allied *Lagenæ* into—1, those with square meshes (*L. Melo*); 2, those with six-sided meshes (*L. hexagona*, Will. *L. favosa*, Reuss); and 3, those with both four- and six-sided meshes (*L. squamosa*, Mont.). The last two groups may be conveniently treated of together, as below. *Lagena Melo* is not uncommon in company with other members of the group, though not so frequent as the smooth, sulcate, honeycombed, and marginate varieties; and it has the same world-wide distribution; it is found fossil also in many Tertiary beds. For its occurrence (recent and fossil) in the Mediterranean area, see ‘Quart. Journ. Geol. Soc.,’ vol. xvi, Table, p. 302.

In the Crag it appears confined to the bed at Gedgrave, containing *Cardita senilis*; and the specimens are rare.

7. LAGENA SQUAMOSA, *Montagu*. Plate IV, fig. 7.

- VERMICULUM SQUAMOSUM, *Montagu*, 1803. Test. Brit., p. 526, pl. 14, fig. 2.
 SERPULA SQUAMOSA, *Maton and Rackett*, 1807. Trans. Linn. Soc., vol. viii, p. 247.
 — — *Turton*, 1819. Conch. Dict., p. 158.
 LAGENULA — *Fleming*, 1828. Brit. Animals, p. 235.
 — RETICULATA, *Macgillivray*, 1843. Moll. Anim. Aberdeen, p. 28.
 — SQUAMOSA, L. RETICULATA, *Thorpe*, 1844. Brit. Mar. Conch., pp. 234, 235.
 ENTOSOLENIA — *Williamson*, 1848. Ann. Nat. Hist., 2nd ser., vol. i, pl. 2, fig. 19.
 — — var. γ HEXAGONA, *Id.* Ib., fig. 23.
 — GLOBOSA, var. SQUAMOSA, *Parker and Jones*, 1857. Ann. Nat. Hist., 2nd ser., vol. xix, p. 278, pl. 11, fig. 25.
 — SQUAMOSA (typica), *Will.*, 1858. Rec. For. Br., p. 12, pl. 1, fig. 29.
 — — var. SCALARIFORMIS, *Id.* Ib., p. 13, pl. 1, fig. 30.
 — — var. HEXAGONA, *Id.* Ib., fig. 32.
 LAGENA RETICULATA, *Reuss*, 1862. Sitz. Akad. Wien., vol. xlii, p. 333, pl. 5, figs. 67, 68.
 — SCALARIFORMIS (parte), *Id.* Ib., figs. 69, 70.
 — FAVOSA, *Id.* Ib., p. 334, pl. 5, figs. 72, 73.
 — GEOMETRICA, *Id.* Ib., fig. 74.
 OVULINA ORNATA, *Seguenza*, 1862. Foram. Monotal. Miocen. Messin., pl. 42, p. 1, fig. 12.
 PHIALINA — *Id.* Ib., p. 48, pl. 1, fig. 30.
 LAGENA SQUAMOSA, *P. and J.*, 1862. Append. Carpenter’s Introd., p. 309.
 — — *Brady*, 1864. Trans. Linn. Soc., vol. xxiv, p. 472; 1865, Nat. Hist. Trans. Northumb. and Durham, vol. i, p. 97.
 — SULCATA, var. SQUAMOSA, *P. and J.*, 1865. Phil. Trans., vol. clv, p. 354, pl. 13, figs. 40, 41; pl. 16, fig. 11.
 — ANOMALA, *Stache*, 1865. Novara-Exped., Geol. Theil., vol. i, part 2, p. 183, pl. 22, fig. 5.

Characters.—Shell ovato-globose or pear-shaped, usually Entosolenian. Surface covered with an ornamentation of elevated ridges, forming a network with hexagonal or sub-hexagonal meshes. Colour white to yellowish. Length $\frac{1}{100}$ th or less to $\frac{1}{50}$ th inch.

This represents a state of ornamentation peculiar to the *Lagenæ* amongst the “hyaline,” and to certain varieties of *Miliola seminulum* among the “porcellaneous” Foraminifera. In *L. Melo* the cross-bars are often weaker than the longitudinal ribs, and pass straight across from rib to rib, like the secondary veins in a monocotyledonous leaf, such as *Alisma*, *Myrsiphyllum*, &c. In *L. squamosa*, however, not only have the secondary riblets become equal to the primary, but, by the zigzag inflection of the latter, a nearly regular hexagonally areolated ornament is produced, reminding one strongly of the polygonal meshes produced by the more perfect reticulation of the woody skeleton of a dicotyledonous leaf. Early observers, using but imperfect microscopes, compared this retose ornament with a scaly skin of a fish (see Williamson, ‘Monograph,’ p. 12), and, indeed, from young and small specimens, mounted in Canada balsam and viewed as transparent objects, it would be almost impossible, even with the best instruments, to contradict such a diagnosis.

Professor Reuss, in his ‘Memoir on the *Lagenidæ*,’ pl. 5, fig. 74, figures, under the name of *L. geometrica*, a very beautiful modification of this variety, in which the ornament takes the form of very small, regular, hexagonal meshes, separated by delicately thin elevated walls. Professor Williamson’s figure (‘Monogr.,’ pl. 1, fig. 32) of *L. squamosa*, var. *hexagona*, represents a similarly regular marking, but here the ridges are broader, and the number of meshes finer. His *L. squamosa*, var. *scalariformis*, has the same general character, but there is proportionately a smaller amount of ornament, and the interstitial spaces are still larger.

In this reticulate *Lagena* the neck is usually intussuscepted (Entosolenian); but in one of the large fossil form (*L. squamoso-tubifera*, Parker and Jones, ‘Phil. Trans.,’ 1865, pl. 18, fig. 7), the neck is protruded in some cases to a considerable extent, and has about three secondary tubular apertures arising from it laterally, and almost at right angles to the main tube. This is an isomorphism with *Polymorphina tubulosa*, and with certain feeble bifurcating forms of *Nodosaria* from Cretaceous beds.

L. squamosa is of world-wide occurrence; but, like *L. Melo*, is not so abundant as the long flask-shaped and the marginated forms. In the Arctic Seas it is not uncommon, and on our own shores it is found sparingly everywhere. It is found fossil in the Black Crag of Antwerp (Reuss), and in the Tertiary clays of North Italy. By far the bulkiest specimens of *L. squamosa* that we have seen are from a Tertiary sand, which, rich in many varieties of *Lagenæ*, in *Ovulites*, *Polymorphina*, and *Vertebralina*, was taken from the inside of a *Cerithium giganteum* from Grignon. A single specimen collected by Mr. H. C. Sorby, at Bridlington, kindly placed in our hands with his other specimens from the same locality, is the only instance we know of its occurrence in the Pliocene beds of Britain.

8. LAGENA MARGINATA, *Walker and Jacob*. Plate I, figs. 33, 34.

- Serpula* (*Lagena*) *marginata*, *Walker and Jacob*, 1784. Test. Min., p. 3, pl. 1, fig. 7.
VERMICULUM MARGINATUM, *Montagu*, 1803. Test. Brit., p. 524.
SERPULA MARGINATA, *Maton and Rackett*, 1807. Trans. Linn. Soc., vol. viii, p. 247.
OOLINA COMPRESSA, *D'Orb.*, 1839. Foram. Amér. Mérid., p. 18, pl. 5, figs. 1, 2.
LAGENULA MARGINATA, *Thorpe*, 1844. Brit. Mar. Conch., p. 234.
OOLINA COMPRESSA, *D'Orb.*, 1846. For. Fos. Vien., p. 24, pl. 21, figs. 1, 2.
ENTOSOLENIA MARGINATA, *Williamson*, 1848. Ann. Nat. Hist., 2nd ser., vol. i, p. 17, figs. 15—17.
FISSURINA LÆVIGATA, *Reuss*, 1849. Denks. Akad. Wien., vol. i, p. 366, pl. 46, fig. 1.
— *ALATA*, *Id.*, 1851. Zeits. Deut. Geol. Ges., vol. iii, p. 58, pl. 3, fig. 1.
— *GLOBOSA*, *Bornemann*, 1856. Zeits. Deut. Geol. Ges., vol. vii, p. 315, pl. 12, fig. 4.
ENTOSOLENIA — var. *MARGINATA*, *P. and J.*, 1857. Ann. Nat. Hist., 2nd ser., vol. xix, p. 278, pl. 11, figs. 28, 29.
— *MARGINATA*, *Will.*, 1858. Rec. For. Br., p. 10, pl. 1, figs. 19—21.
— — varr. *LUCIDA*, *QUADRATA*, *Id.* Ib., pp. 10, 11, pl. 1, figs. 22, 23, 27, 28.
FISSURINA OBLONGA, *Reuss*, 1858. Sitz. Akad. Wien., 1862, vol. xlvi, p. 339, pl. 7, fig. 89.
— *CARINATA*, *Id.*, 1862. Ib., vol. xlvi, p. 338, pl. 6, fig. 83; pl. 7, fig. 86.
LAGENA MARGINATA, *P. and J.*, 1862. Append. Carpenter's Introd., p. 309.
FISSURINA SIMPLEX, *Seguenza*, 1862. Foram. Monotal. Miocen. Messin., p. 56, pl. 1, fig. 44.
— *DELTOIDEA*, *Id.* Ib., p. 57, pl. 1, fig. 45.
— *LATISTOMA*, *Id.* Ib., figs. 46, 47.
— *BIANCÆ*, *Id.* Ib., figs. 48—50.
— *ACUTA*, *Id.* Ib., fig. 51.
— *PECCHIOLI*, *Id.* Ib., p. 58, pl. 1, fig. 52.
— *COMMUNIS*, *Id.* Ib., p. 59, pl. 1, figs. 56, 57.
— *PROPINQUA*, *Id.* Ib., fig. 58.
— *ARADASH*, *Id.* Ib., fig. 59.
— *APERTA*, *Id.* Ib., p. 60, pl. 1, fig. 60.
— *OBVIA*, *Id.* Ib., pl. 2, fig. 1.
— *TENUIS*, *Id.* Ib., fig. 2.
— *ELLIPTICA*, *Id.* Ib., fig. 3.
— *OVATA*, *Id.* Ib., p. 62, pl. 2, figs. 9, 10.
— *BENOITIANA*, *Id.* Ib., fig. 11.
— *HAECKELII*, *Id.* Ib., p. 63, pl. 2, fig. 13.
— *INÆQUALIS*, *Id.* Ib., fig. 14.
— *CIRCULUM*, *Id.* Ib., fig. 15.
— *SILVESTRII*, *Id.* Ib., p. 64, pl. 2, fig. 18.
— *EMARGINATA*, *Id.* Ib., p. 65, pl. 2, fig. 20.

FISSURINA DILATATA, <i>Seguenza</i> , 1862.	For. Monot. Mioc. Messin., p. 65, pl. 2, fig. 21.
— LÆVIS, <i>Id.</i>	Ib., p. 66, pl. 2, figs. 22, 23.
— ROMETTENSIS, <i>Id.</i>	Ib., fig. 24.
— ORBIGNYANA, <i>Id.</i>	Ib., figs. 25, 26.
— MARGINATA, <i>Id.</i>	Ib., figs. 27, 28.
— SULCATA, <i>Id.</i>	Ib., p. 67, pl. 2, fig. 29.
— TUBULOSA, <i>Id.</i>	Ib., p. 68, pl. 2, figs. 36, 37.
— COSTÆ, <i>Id.</i>	Ib., p. 69, pl. 2, fig. 38.
— ELEGANS, <i>Id.</i>	Ib., fig. 39.
— GEMELLARII, <i>Id.</i>	Ib., p. 70, pl. 2, fig. 45.
— REGULARIS, <i>Id.</i>	Ib., p. 71, pl. 2, fig. 46.
— SARTORII, <i>Id.</i>	Ib., fig. 47.
— LYELLII, <i>Id.</i>	Ib., figs. 48, 49.
— RIZZAE, <i>Id.</i>	Ib., fig. 50.
AMYGDALINA TRUNCATA, <i>Id.</i>	Ib. p. 73, pl. 2, figs. 52, 53.
LAGENA MARGINATA, <i>Brady</i> , 1864.	Trans. Linn. Soc., vol. xxiv. p. 472.
— SULCATA, var. (ENTOSOLENIA) MARGINATA, <i>P. and J.</i> , 1865.	Phil. Trans., vol. clv, p. 355, pl. 13, figs. 42—44; pl. 16, fig. 12.

Characters.—Shell orbicular, compressed, with a more or less prominent marginal ridge or carina. Tube either Ectosolenian or Entosolenian. Aperture oval or slit-like. Surface smooth. Colour white or dirty white. Length $\frac{1}{100}$ th or less to $\frac{1}{30}$ th inch.

Under the general name *Lagena marginata* are included a large number of flattened forms, variable in shape, generally Entosolenian, but sometimes Ectosolenian with a long delicate neck. This compressed shape is usually associated with a trenchant margin, sometimes slightly apiculated, and sometimes dentate or rowelled (as in Williamson's 'Monograph,' pl. 1, figs. 21 *a*, 25, 26), reminding us of the keel of certain *Cristellariæ*. Occasionally, in large well-developed specimens of *L. marginata* (recent and fossil) the margin is composed of a large predominant rib, strengthened by a pair of smaller costæ (*L. fasciata*, Egger, &c.), showing that, as in other Foraminifera, especially the Nodosarine group, the exogenous costæ gather themselves to the margins, the rest of the surface becoming less and less ornamented. The pseudopodial pores also usually affect the neighbourhood of the thickened margin in these flattened forms, just as they follow the ridges of *L. striato-punctata*. Occasionally the pseudopodia have perforated the whole surface, either sparsely, or freely, as we have seen in specimens from the Indian Sea. In some rare specimens from the Coral-reefs of Australia, and fossil at Bordeaux, we see the pseudopodia begin to enter the shell-wall near the centre, and then burrow radially to escape near the margin, the shell-surface being perfectly smooth and as polished as glass (*L. radiato-marginata*, P. & J.).

The intussuscepted neck-tube in *L. marginata* is generally more or less oblique, somewhat trumpet-shaped, and of varying length. The apparent difference in the setting on of the mouth, which we formerly thought we could detect, between *Entosolenia* and *Lagena* proper ('Annals Nat. Hist.,' 2nd ser., vol. xix, p. 279) does not really

exist; for we find that in any of the subspecific groups forms may occur having either a gently tapering neck (Ectosolenian), or a tube abruptly set in (Ento-ecto-solenian), or a mouth-tube entirely intussuscepted (Entosolenian). *L. marginata* is sometimes distomatous, being open at the base, and then coming under another (artificial) subdivision.

No division of the species can be made depending on the general form of the shell; from nearly globose to the most compressed and carinate specimen every gradation of contour may be shown.

The distribution of *Lagena marginata* is world-wide. Professor Williamson has recorded its occurrence at 100 fathoms at the Hunde Islands ('Monogr.,' pp. 10, 11); and we have found it in Dr. Sutherland's dredgings from the same locality (30 to 70 fathoms), as well as in Messrs. MacAndrew and Barrett's material brought from Drontheim, North Cape (30 to 200 fathoms). On our own shores it is common everywhere. For some of its Mediterranean habitats (recent and fossil) see 'Quart. Journ. Geol. Soc.,' vol. xvi, p. 302, Table. Under the name of *Oolina compressa*, D'Orbigny described it as occurring with other *Lagenæ* at the Falkland Isles. It is figured by J. D. Macdonald, Assist. Surgeon H. M. S. Herald, in the 'Annals Nat. Hist.,' 2nd ser., vol. xx, pl. 5, figs. 7—10, but not described. He found it, together with *Uvigerina dimorpha*, *Spiroloculina planata*, *Quinqueloculina seminulum*, and *Triloculina oblonga*, in 400 fathoms water, between Ngaa and Viti-Laru, in the Fiji group of islands. We have seen specimens hexagonally areolated, like *L. squamosa*, but less distinctly so, from the Tertiary beds of San Domingo, and from the white mud of the Australian Coral-reefs (*L. squamoso-marginata*, P. and J.).

Large specimens of *L. marginata* are not uncommon in the Crag with *Cyprina Islandica*; and, less finely grown, it is frequent in the Gedgrave bed with *Cardita senilis*.

9. LAGENA ORNATA, *Williamson*. Plate I, figs. 29—31.

ENTOSOLENIA MARGINATA, var. ORNATA, *Williamson*, 1858. Rec. For. Brit., p. 11, pl. 1, fig. 24.

— — var. LAGENOIDES, *Id.* Ib., figs. 25, 26.

LAGENA LAGENOIDES, *Reuss*, 1862. Sitz. Akad. Wien., xlv, p. 324, pl. 2, figs. 27, 28.

FISSURINA TRAPEZOIDEA, *Seguenza*, 1862. Foram. Monot. Mioc. Mess., p. 68, pl. 2, fig. 34.

— REUSSIANA, *Id.* Ib., p. 69, pl. 2, fig. 40.

— RADIATA, *Id.* Ib., p. 70, pl. 2, figs. 42, 43.

Characters.—Flask-shaped, with or without neck; either Ento- or Ecto-solenian, or both, more or less compressed, and having its margin produced to a variable extent, and

traversed by pseudopodial tubes, with a somewhat radial arrangement, often giving the margin the appearance sometimes of being more or less regular plicated.

Length $\frac{1}{45}$ th inch.

In fact, we have in this case one of the subvarieties of *Lagena marginata* mentioned in 'Phil. Trans.,' 1865, p. 335, and alluded to above in our account of the last-named form. Among the several modifications of the type, this presents one with the radiating canals visible only at the margin. Prof. Williamson's *Entosolenia marginata*, var. *ornata*, especially possesses the subtypical character above mentioned; and his *E. marginata*, var. *lagenoides*, as represented by the fig. 26 in his 'Monograph' (badly copied in Prof. Reuss's 'Monograph of the *Lagenida*,' 1862, pl. 2, fig. 27, and misnamed "*appendiculata*" in the plate), has this character plain enough, though not so symmetrically perfect as in our specimen from the Crag. Prof. Seguenza has recorded some beautiful specimens; his *Fissurina trapezoides* is almost identically the same as Williamson's fig. 26; but his *F. radiata* and *F. Reussiana* are beautiful developments of the same form; indeed, we regret that the exigencies of zoological nomenclature debar us from keeping our highly esteemed German friend's name permanently associated with so elegant a *Lagena*.

L. ornata, with its neatly radiate margin, does not seem to be a very rare form among other *Lagenæ* (Davis' Straits and British coast, recent; Sicily, fossil); besides two or three small specimens, we have from the Crag of Sutton one at least as beautiful as Seguenza's *L. Reussiana*.

10. LAGENA APICULATA, Reuss. Plate I, fig. 27.

OOLINA APICULATA,	Reuss, 1850.	Haiding. Nat. Abhandl., vol. iv, p. 22, pl. 1, fig. 1.
LAGENA —	Id., 1862.	Sitz. Akad. Wien., vol. xlv, p. 319, pl. 1, figs. 4—8, 10, 11.
FISSURINA ACUTA,	Id.	Ib., p. 340, pl. 7, figs. 40, 41.
OVULINA CAUDIGERA,	Seguenza, 1862.	Foram. Mon. Mioc. Mess., p. 39, pl. 1, fig. 3.
— PERFORATA,	Id.	Ib., p. 40, pl. 1, fig. 4.
AMPHORINA GLOBOSA,	Id.	Ib., p. 50, pl. 1, fig. 31.
— TENUICALCAR,	Id.	Ib., fig. 32.
— ELONGATA,	Id.	Ib., fig. 34.
LAGENA SULCATA, var. (ENTOSOLENIA) APICULATA et CAUDATA,	P. and J., 1865.	Phil. Trans., vol. clv, p. 358.

Characters.—Shell oval, subspherical, or flask-shaped; smooth, with the base either merely apiculate, or drawn out into a tubular prolongation.

Length $\frac{1}{100}$ th inch and upwards.

Similar forms are often ornamented with striæ and costulæ, such as *L. caudata*, D'Orb.; and the two groups together, as we have already noticed (p. 35), when referring to our scheme of the division of the *Lagenæ*, may be referred to under that name, as an intermediate

set of forms, leading from the common round-based varieties towards the distomatous series.

These smooth apiculate *Lagenæ*, or smooth subvarieties of *L. caudata*, D'Orb., are found in many places in company with the common *Lagenæ*, and they are fossil in the Tertiary strata. One or two small specimens only have occurred to us in the Crag of Sutton.

11. LAGENA GRACILLIMA, *Seguenza*. Plate I, figs. 36, 37.

MILIOLA LÆVIS, *Ehrenberg* (parte), 1845. Mikrogeol., part 2, p. 22, pl. 26, fig. 2.

LAGENA LÆVIS, *Parker and Jones*, 1857. Ann. N. Hist., 2nd ser., vol. xix, p. 278, pl. 11, fig. 23.

AMPHORINA ACUMINATA, *Seguenza*, 1862. Foram. Monotal. Mioc. Messin., p. 51, pl. 1, fig. 35.

— CYLINDRACEA, *Id.* Ib., fig. 36.

— GRACILLIMA, *Id.* Ib., fig. 37.

— DISTORTA, *Id.* Ib., p. 52, pl. 1, fig. 38.

LAGENA SULCATA, var. DISTOMA-POLITA, *Parker and Jones*, 1865. Phil. Trans., vol. clv, p. 357, pl. 13, fig. 21; pl. 18, fig. 8.

Characters.—Shell much elongated, fusiform, distomatous, often twisted or curved. Both extremities subulate. Surface smooth. The hyaline texture of the young shell becomes opaque white in older specimens.

Length $\frac{1}{36}$ th to $\frac{1}{8}$ th inch

This may be regarded as the distomatous form, corresponding to *L. lævis* in the single-mouthed series. Although it has been found elsewhere, both in recent and fossil condition, we have never seen specimens approaching those from the Crag in point of size, except from the Red Sea and Australia; indeed, those in Mr. Wood's collection from Sutton are the largest *Lagenæ* with which we are acquainted.

Fig. 37, Plate I, represents a portion of the shell more highly magnified, and shows very beautifully its foraminated structure. It may be constantly noticed, in examining the shells of *Lagenæ* under high powers, that the amount of perforation varies with the thickness of the wall; that in the thinner, more delicate portions the foramina are few and indistinct, whilst in those places in which it assumes stouter proportions the surface is closely studded with dots indicating the open ends of the tubuli.

Distomatous *Lagenæ* are by no means common. The best-known form has an elongated, straight-sided shell, with delicate, parallel, longitudinal striæ (*Lagena distoma*, P. and J.), occasionally found in deepest soundings in the Northern Seas.

Seguenza, in his 'Monografia dei Foraminiferi Monotalamici delle Marne Mioceniche Messinesi,' figures four smooth-shelled double-mouthed specimens with as many different specific names. Three of these are symmetrical, and one of them (fig. 37) the exact counter-

part of *L. distoma-polita*, P. and J., from Australia; the fourth (*Amphorina distorta*) is unsymmetrical, and altogether analogous to those found in the Crag.

We choose the term "*gracillima*," as having been applied to the most typical form. Seguenza's *Amphorina globosa*, *Am. tenuicalcar*, *Am. olivæformis*, and *Am. elongata* (figs. 31—34), are *apiculate* individuals standing between *Lagena gracillima* and *L. lævis*.

Lagena gracillima (under one modification or another) occurs on the Norwegian coast and in the Red Sea, on the beach near Melbourne, at Swan River, and on the Australian Coral-reefs. One or two specimens are also reported from the Durham coast.

In the Crag it has hitherto been found only in the Sutton beds. It is not uncommon in the Tertiary marl of Sicily, examined by Prof. Seguenza.

Genus—NODOSARINA, Parker and Jones.

NAUTILUS, ORTHOCERAS (parte), ORTHOCERA, NODOSARIA, ELLIPSOIDINA (?), GLANDULINA, MUCRONINA, LINGULINA, FISSURINA, AMPHIMORPHINA, FRONDICULARIA, FLABELLINA, DENTALINA, DENTALINOPSIS, VAGINULINA, RIMULINA, MARGINULINA, PSECAIDIUM, LINGULINOPSIS, HEMICRISTELLARIA, HEMIROBULINA, SARACENARIA, CRISTELLARIA, ROBULINA, PLANULARIA, &c., *Auctorum*.¹

General characters.—Shell hyaline, tubuliferous, either straight, arcuate, or discospiral; composed of several segments, arranged in one series. Pseudopodial orifice terminal and single, either central or excentric. Surface smooth, or ornamented with straight, raised, parallel lines, either continuous or interrupted, sometimes reduced to spines or granules, sometimes replaced by one or more keels.

Nodosarina (*Marginulina*) *raphanus* is the central form of a large series of Foraminifera, whose constant variation in respect to degree of curvature, excentricity of aperture, with greater or less flatness or compression, has given rise to the most unphilosophical splitting up of what is practically a single species into an almost infinite number of pseudo-specific forms. The so-called genera and subgenera *Glandulina*, *Nodosaria*, *Lingulina*, *Frondicularia*, *Flabellina*, *Rimulina*, *Dentalina*, *Vaginulina*, *Marginulina*, *Planularia*, *Cristellaria*, &c., have in this way all been constituted on characters of scarcely varietal significance. With some exceptions, however, they have a certain value of convenience, which induces us, as in other cases, to admit them as representing divisions or groups in an otherwise unwieldy genus, which have certain peculiarities in common, though it would not be difficult to find a series of specimens which should exhibit every variation, from the straightest and most elongated *Nodosaria* to the most lenticular and carinate *Cristellaria*. We shall speak of these groups as subgenera, for want of a better title.

¹ Ehrenberg applied the term "*Nodosarina*" (Berlin Acad. Transact. for 1838) to a corresponding group of *Foraminifera*, as a Family of the Polythalamian Order of his "*Bryozoa*."

Subgenus—GLANDULINA, *D'Orbigny*.

NAUTILUS (ORTHOCERAS), *Batsch*.

NODOSARIA (GLANDULINA), *D'Orbigny, Parker and Jones, Carpenter*.

GLANDULINA, *D'Orbigny, Reuss, Brown, Morris, Bornemann, Brady, &c.*

Characters.—Shell acute-ovate. Chambers few in number, short, subcylindrical, or slightly ventricose; each successive chamber much larger than the preceding one, and embracing a large portion of it. Aperture central.

1. GLANDULINA LÆVIGATA, *D'Orbigny*. Plate I, figs. 1, 2.

NODOSARIA (GLANDULINA) LÆVIGATA, *D'Orb.*, 1826. Ann. Sc. Nat., vol. vii, p. 252, No. 1, pl. 10, figs. 1—3.

GLANDULINA LÆVIGATA, *D'Orb.*, 1846. For. Fos. Vien., p. 29, pl. 1, figs. 4, 5.

— OVULA, *Id.* Ib., figs. 6, 7.

— PYGMÆA, GL. MANIFESTA, *Reuss*, 1851. Haid. Nat. Abhandl., vol. iv, p. 22, pl. 2, figs. 3, 4.

— ROTUNDATA, *Bornemann*, 1854. Liasform. Göttingen, p. 31, pl. 2, figs. 1, 2.

— INFLATA, *Born.*, 1855. Zeits. Deut. Geol. Ges., vol. vii, p. 16, pl. 1, figs. 6, 7.

— LÆVIGATA, *Id.* Ib., fig. 8.

— ELONGATA, *Id.* Ib., fig. 9.

— CONCINNA, *Reuss*, 1855. Zeits. Deut. Geol. Ges., vol. vii, p. 263, pl. 8, fig. 1.

— LÆVIGATA, *Neugeboren*, 1856. Denksch. Math.-Nat. Cl. Akad. Wissen. Wien., vol. xii, p. 67, pl. 1, figs. 3, 4.

— ABBREVIATA, *Id.* Ib., p. 68, pl. 1, fig. 1.

NODOSARIA LÆVIGATA, *Parker and Jones*, 1857. Ann. Nat. Hist., 2nd ser., vol. xix, p. 280, pl. 10, figs. 6—8.

— GLANS, *Id.*, 1860. Quart. Journ. Geol. Soc., vol. xvi, p. 453, pl. 19, fig. 7.

GLANDULINA ELLIPTICA, *Reuss*, 1864. Sitzungsab. Akad. Wien., vol. xlviii, p. 47, pl. 3, figs. 29—31.

— LÆVIGATA, *Brady*, 1864. Trans. Linn. Soc., vol. xxiv, p. 468, pl. 48, fig. 7.

— STROBILUS, *Reuss*, 1865. Denks. Akad. Wien., Math.-Nat. Cl., vol. xxv, p. 20, pl. 2, fig. 24.

— GRACILIS, *Id.* Ib., p. 21, pl. 2, figs. 25—27.

— LÆVIGATA, var. INFLATA, *Id.* Ib., p. 20, pl. 2, figs. 29—31.

NODOSARIA (GLANDULINA) LÆVIGATA, *Parker and Jones*, 1865. Phil. Trans., vol. clv, p. 340, pl. 13, fig. 1.

GLANDULINA ANNULATA, *Stache*, 1865. Novara-Exped., Geol. Theil, part 2, p. 184, pl. 22, fig. 6.

— SUBOVATA, *Id.* Ib., p. 185, pl. 22, fig. 7.

— NAPEFORMIS, *Id.* Ib., p. 186, pl. 22, fig. 8.

Characters.—Shell more or less acutely ovate or subfusiform, composed of short sub-cylindrical chambers, few in number, and increasing rapidly in size with the growth of the shell. Pseudopodial aperture at the summit of the terminal chamber, usually round, but becoming more slit-like when the chambers become compressed. Surface smooth. The striate variety is known as *Gl. glans*, D'Orb. Length about $\frac{1}{24}$ th inch.

Glandulina lævigata is an interesting subtypical form of *Nodosarina*, distinguished from *Nodosariæ* proper by its short, subglobular, fusiform shape. On the other hand, it is frequently almost impossible to separate the Glanduline from the short Linguline varieties of the type, which often differ in nothing save an inappreciable amount of flattening in the shells of the latter.

The specimens from Sutton in Mr. Searles Wood's collection are somewhat above the average size; and, from their number, *Gl. lævigata* appears to have been a tolerably common form in the beds examined by him.

In comparison with the other *Nodosarina*, *Glandulina* is nowhere abundant in a recent state. In the muddy bed of the Gulf of Suez at 30 to 40 fathoms, in the Mediterranean at from 30 to 100 fathoms, off Shetland at about 70 fathoms, off the Norwegian coast at a similar depth, and within the Arctic Circle at 160 fathoms, it is to be found sparingly distributed.

It is less rare in a fossil condition, though the examples are generally very small, and may be met with in the Upper Triassic Clay of Chellaston, in many Liassic marls, in the Oxford Clay of Leighton-Buzzard, the Kimmeridge Clay of Aylesbury, in the Chalk-marl of the South-east of England, and in the Tertiaries of Europe, New Zealand, &c.

Subgenus—NODOSARIA, Lamarck.

NAUTILUS, Linné, Schroeter, Walker, Gmelin, Batsch, Turton, Montagu, Maton and Rackett, Pennant, Dillwyn, Wodarch, W. Wood, &c.

ORTHOCERAS, Gualtieri, Martini, Batsch, De Blainville, Hanley, &c.

ORTHOCERA, Lamarck, Brookes, De Blainville, Crouch, Brown, Fleming, Thorpe, &c.

NODOSARIA, Lamarck, DeFrance, D'Orbigny, Nilsson, Crouch, Brown, Sowerby, Dujardin, Hisinger, Roemer, Geinitz, Hanley, Ehrenberg, Michelotti, Hagenow, Morris, Thorpe, Philippi, Reuss, Czjzek, Bronn, M^r Coy, Bailey, Eichwald, Bornemann, Schultze, Neuegeboren, Egger, Parker and Jones, Williamson, Terquem, Costa, Karrer, Carpenter, Brady, Stache, &c.

General characters.—Shell cylindrical, composed of several nearly equal segments, arranged in a straight series; either smooth or ornamented with ribs, granules, or spines; septal lines more or less depressed, making constrictions at right angles to the long axis of the shell. Pseudopodial aperture simple, central, often pouting.

1. NODOSARIA RAPHANUS, *Linné*, sp. Plate I, figs. 4, 5, 22, 23.

Cornu Hammonis erectum, &c., *Plancus*, 1739. Conchis minus notis, p. 15, pl. 1, figs. 6, D—H.

Orthoceras minimum, &c., *Gualtieri*, 1742. Index Test., pl. 19, figs. L, L, LL, M.

NAUTILUS RAPHANUS, *Linné*, 1758. Syst. Nat., 10th ed., p. 711, No. 243; 1767, Syst. Nat., 12th ed., p. 1164, No. 283.

Cornu Ammonis, &c., *Ledermüller*, 1760. Mikroskop. Gemuths., &c., p. 9, pl. 4, figs. x, x.

ORTHOCERAS, *Martini*, 1769. Neu. Syst. Konch. Kab., vol. i, p. 1 and p. 34, vignette 1, figs. A, B, C.

ORTHOCERA RAPHANOIDES, *Lamarck*, 1801. Syst. des Anim., p. 103.

NAUTILUS (ORTHOCERAS) COSTATUS, *Batsch*, 1791. Conchyl. Seesand., pl. 1, figs. 1 a—1 g.

— COSTATUS, *Montagu*, 1803. Test. Brit., vol. i, p. 199, pl. 14, fig. 5.

ORTHOCERA RAPHANUS, *Lamarck*, 1816. Encycl. Méth., pl. 465, figs. 2 a, b, c; 1822, Anim. sans Vert., vol. vii, p. 593, No. 1.

NAUTILUS RAPHANUS, *Dillwynn*, 1817. Descript. Cat. Rec. Shells, vol. i, p. 347.

NODOSARIA ACICULA, *Lamarck*, 1822. Anim. sans Vert., vol. vii, p. 594, No. 5.

— LAMELLOSA, *D'Orb.*, 1826. Ann. Sc. Nat., vol. vii, p. 253, No. 17, pl. 10, figs. 4—6.

— RAPA, *Id.* Ib., No. 27.

ORTHOCERA RAPHANUS, *Crouch*, 1827. Illust. Introd. Conch., p. 39, pl. 20, fig. 5.

NAUTILUS RAPHANISTRUM, N. RAPHANUS, *W. Wood*, 1828. Suppl. Index Test., p. 64, pl. 13, figs. 23, 24.

ARTICULINA, *Wetherell* and *Sowerby*, 1834. Trans. Geol. Soc., 2nd ser., vol. v, p. 135, pl. 9, fig. 10.

NODOSARIA PAUCICOSTATA, *Roemer*, 1840. Verst. Nordd. Kreid., p. 96, pl. 15, fig. 7.

— TENUICOSTA, *Reuss*, 1845. Verst. Böhm. Kreid. I, p. 25, pl. 13, figs. 5, 6.

— OBSCURA, *Id.* Ib., p. 26, pl. 13, figs. 7—9.

— SULCATA, *Id.* Ib., p. 26, pl. 13, fig. 17.

— BOLLI, *Reuss*, 1855. Zeits. Deut. Geol. Ges., vol. vii, p. 262, pl. 8, fig. 6.

ORTHOCERA RAPHANUS, *Hanley*, 1855. Ipsa Linn. Conch., p. 159.

— RAPHANISTRUM, O. RAPHANUS, *Hanley*, 1856. Wood's Index Test., p. 74, pl. 13, figs. 23, 24.

DENTALINA SUBARCUATA, var. JUGOSA (parte), *Williamson*, 1858. Rec. Fos. Gr. Brit., p. 20, pl. 2, fig. 43.

NODOSARIA RAPHANUS, *Parker* and *Jones*, 1859. Ann. N. Hist., 3rd ser., vol. iii, p. 477, &c.; 1865, Phil. Trans., vol. clv, p. 340, pl. 16, fig. 1.

DENTALINA PULCHRA, *Gabb*, 1860. Journ. Acad. Sc. Philadelphia, new series, vol. iv, part 4, p. 402, pl. 69, figs. 40, 41.

NODOSARIA DUPLICOSTATA, *Reuss*, 1860. Sitz. Akad. Wien., vol. xl, p. 179, pl. 1, fig. 5.

— RAPHANUS, *Brady*, 1864. Trans. Linn. Soc., vol. xxiv, p. 473.

— STRIATISSIMA, *Stache*, 1865. Novara-Exped., Geol. Theil, I Band, II Abtheil., p. 198, pl. 22, fig. 25.

DENTALINA STRIATISSIMA, *Stache*, 1865. Novara-Exped., Geol. Theil, I Band, II Abtheil., p. 200, pl. 22, fig. 38.

NODOSARIA (DENTALINA) LUDWIGI, *Reuss*, 1866. Denks. Math.-Nat. Cl. Akad. Wissen., vol. xxv, p. 19, pl. 2, fig. 23.

Characters.—Shell straight, subcylindrical, tapering, composed of a few largish chambers, and externally ribbed from end to end by stout parallel ridges. The constrictions marking the septal lines are sometimes concealed by the overgrowing longitudinal costæ. Liable to become either curved or compressed, or both, with more or less excentric aperture; and thereby passing into either *Dentalina* or *Marginulina*.

Length $\frac{1}{36}$ th to $\frac{1}{4}$ th inch and more.

It would be impossible to define exactly the limits between *Nodosaria raphanus* and the two forms which follow it on our list, *N. raphanistrum* and *N. scalaris*. All are straight Nodosarians, and have longitudinal costæ. That there is a considerable amount of varietal distinction, the examination of a few specimens of each would satisfy any observer, and is confirmed by the peculiarities of distribution. In general terms, we may say that the species now under consideration (*N. raphanus*) is the bold, few-chambered, coarse-ribbed, and tapering form; *N. raphanistrum* is a longer and more cylindrical shell, with a larger number of segments, and the ribs more neatly put on; and *N. scalaris* is a few-chambered, more delicate, and transparent shell, seldom growing to a large size, and commonly having an extended neck produced from the terminal chamber.

A specimen from Sutton (Lower Crag) and one from Thorpe (Upper Crag) are the only evidences we have of this species in the Crag; nor is it an abundant form anywhere, except in the Adriatic, where it is frequently Marginuliniform (like our fig. 21), and is associated with arcuate or Dentaline varieties.

In the Lias clays *N. raphanus* is sparingly found where the other *Nodosarinæ* are very common; and in other Secondary and many Tertiary formations it is to be met with.

Professor Williamson figures a broken specimen (fig. 43) from the British seas, but does not give the locality; and we have one or two examples from deep water (70 to 80 fathoms) off Shetland, and several from a similar or greater depth in the Hebrides. It occurs in the North Atlantic (78 fathoms); South Atlantic (Abrolhos Bank, 260 fathoms); and in the Mediterranean and Adriatic seas; but well-developed specimens are rare.

2. NODOSARIA RAPHANISTRUM, *Linn.*, sp. Plate I, figs. 6—8.

NAUTILUS RAPHANISTRUM, *Linn.*, 1758. Syst. Nat., 10th ed., p. 710, No. 242; 1767, Syst. Nat., 12th ed., p. 1163, No. 282.

NAUTILUS COSTATUS, var., *Montagu*, 1808. Test. Brit. Supp., p. 83, pl. 19, fig. 2.

ORTHOCERA RAPHANISTRUM, *Lamarck*, 1822. An. s. Vert., p. 594, No. 3.

— — — *De Blainville*, 1824. Dict. Sc. Nat., vol. xxxvi, p. 486.

NODOSARIA BACILLUM, *Defrance*, 1825. Ib., vol. xxxv, p. 127; vol. xxvi, p. 487, Atlas Conch., pl. 13, fig. 4.

- NODOSARIA BACILLUM, *D'Orb.*, 1826. Ann. Sc. Nat., vol. vii, p. 254, No. 34.
- ORTHOCERA, *Woodward*, 1833. Geol. Norfolk, pl. 6, fig. 24.
- ARTICULINA, *Wetherell and Sowerby*, 1834. Trans. Geol. Soc., 2nd ser., vol. v, p. 135, pl. 9, fig. 9.
- NODOSARIA, *Dujardin*, 1835. Mém. Soc. Géol. Fr., vol. ii, p. 310, pl. 17, fig. 17.
- FILIFORMIS, 1837. Henderson's Edition of Cuvier's 'Animal Kingdom,' vol. iii, pl. 8, fig. 10.
- UNDECIMCOSTATA, N. SEPTEMCOSTATA, *Geinitz*, 1839. Charact. Sächs. Kreid., p. 69, pl. 17, figs. 19, 20.
- ÆQUALIS, *G. Sowerby*, 1839. Conchol. Manual, p. 71, fig. 465.
- ACICULA, N. ELEGANS, N. RANZANII, N. CLAVA, *Michelotti*, 1841. Rizopodi Terreni Sopracret. (Mem. Fissica Soc. Ital., vol. xxii, p. 302, pl. 1, figs. 1—4.
- ZIPPEI, *Reuss*, 1844 (?). Kreidegebirg., p. 210; 1845, Verst. Böhm. Kreid. I, p. 25, pl. 8, figs. 1—3.
- PAUPERCULA, *Id.*, 1845. Ib., p. 26, pl. 12, fig. 12.
- BACILLUM, *D'Orb.*, 1846. For. Foss. Vien., p. 40, pl. 1, figs. 40—47.
- AFFINIS, *Id.* Ib., p. 39, pl. 1, figs. 36—39.
- RAPHANISTRUM, *Michelotti*, 1847. Foss. Mioc. Ital. Septent. (Nat. Verhandl. Hollandsch. Maatschap. Wetenschap. Haarlem. Tweede Verzam., 3^e Deel. 2^e Stuk. 1847), p. 12, pl. 1, fig. 7.
- ENNEAGONA, *Alex. Rouault*, 1850. Mém. Soc. Géol. France, 2nd ser., vol. iii, p. 466, pl. 14, figs. 12, 12 a.
- ORTHOCERA RAPHANISTRUM, *Hanley*, 1855. Ipsa Linn. Conch., p. 159, pl. 5, fig. 4.
- NODOSARIA DISTANS, *Reuss*, 1855. Zeits. Deut. Geol. Ges., vol. vii, p. 264, pl. 8, fig. 5.
- POLYGONA, *Id.* Ib., figs. 7, 8.
- COMPRESSIUSCULA, *Neuegeboren* (in part), 1856. Denks. Math.-Nat. Cl. K. Akad. Wiss. Wien., vol. xii, p. 79, pl. 2, figs. 1—7.
- DENTALINA SUBARCUATA, var. JUGOSA (parte), *Williamson*, 1858. Rec. For. Gt. Br., p. 20, pl. 2, fig. 44.
- NODOSARIA INTERCOSTATA, *Reuss*, 1860. Sitz. Akad. Wien., Math.-Nat. Cl., vol. xl, p. 179, pl. 1, fig. 4.
- PRISMATICA, *Id.* Ib., pl. 2, fig. 2.
- RAPHANUS, *Parker and Jones*, 1860. Q. J. Geol. Soc., vol. xvi, p. 453, pl. 19, fig. 10.
- SPECTRUM, *Reuss*, 1862. Sitz. Akad. Wien., Math.-Nat. Cl., vol. xlvi, p. 37, pl. 2, fig. 3.
- TUBIFERA, *Id.* Ib., fig. 4.
- BACTROIDES, *Id.* Ib., fig. 5.
- LAMELLOSO-COSTATA, *Id.* Ib., p. 38, pl. 2, fig. 6.
- PRISMATICA, *Id.* Ib., p. 36, pl. 2, fig. 7.
- MUTABILIS, *Costa* (n. d.). Foram. Foss. Terziar. Messina, p. 8, pl. 1, figs. 1, 2.
- SULCATA, *Id.* Ib., p. 14, pl. 1, fig. 4.
- SUBSIMILIS, *Stache*, 1865. Novara-Exped., Geol. Theil, I Band, II Abtheil., p. 195, pl. 22, fig. 21.

- NODOSARIA SUBSTRIGATA, *Stache*, 1865. *Novara-Exped.*, Geol. Theil, I Band, II Abtheil., p. 196, pl. 22, fig. 22.
- CALLOSA, *Id.* *Ib.*, p. 197, pl. 22, fig. 23.
- OBLIQUECOSTATA, *Id.* *Ib.*, fig. 24.
- BIFORMIS, N. BACTRIDIVM, *Reuss*, 1866. *Denks. Akad. Wien.*, vol. xxv, p. 14, pl. 1, figs. 23—25.
- CONSPURCATA, *Id.* *Ib.*, pl. 2, figs. 19—24.

Characters.—Shell long, straight, cylindrical, many-chambered; septa more or less constricted; surface ornamented by numerous stout parallel ribs running from end to end of the shell. Length $\frac{1}{10}$ th inch to 1 inch and more.

This is the most perfect form of all the straight *Nodosariæ*. When well grown it is a large stout shell, with well-marked characteristic parallel ribs. Taking a curved growth, it becomes *Dentalina obliqua*, Linn.

N. raphanistrum is rare in the Crag at Sutton. It occurs in the Upper Trias, in the Upper, Middle, and Lower Lias, in the Oxford and Kimmeridge Clays, in the Gault and Chalk, in the London Clay, and in various more recent Tertiary clays, such as those of Italy, Spain, and San Domingo. Recent specimens are of rarer occurrence, but are occasionally met with in company with other *Nodosariæ* in the Mediterranean and other seas.

3. NODOSARIA SCALARIS, *Batsch*, sp. Plate IV, fig. 8.

- NAUTILUS (ORTHOCERAS) SCALARIS, *Batsch*, 1791. *Conchyl. Seesands*, pl. 2, figs. 4 *a*, *b*.
- NODOSARIA LONGICAUDA, *D'Orb.*, 1826. *Ann. Sc. Nat.*, vol. vii, p. 254, No. 28; *Soldani, Testac.*, vol. ii, pl. 95, figs. B, M.
- ARTICULINA, *Wetherell and Sowerby*, 1834. *Trans. Geol. Soc.*, ser. 2, vol. v, p. 135, pl. 9, fig. 8.
- NODOSARIA STRIATICOLLIS, *D'Orb.*, 1839. *For. Canaries*, p. 124, pl. 1, figs. 2—4.
- CANDEI, *Id.*, 1840. *For. Cuba*, p. 44, pl. 1, figs. 6, 7.
- CATESBYI, *Id.* *Ib.*, p. 45, pl. 1, figs. 8—10.
- INFLATA, *Reuss*, 1845. *Verst. Böhm. Kreid. I*, p. 25, pl. 13, figs. 3, 4; 1855, *Zeitsch. Deutsch. Geol. Ges.*, vol. vii, p. 262, pl. 8, fig. 2.
- BADENENSIS, *D'Orb.*, 1846. *For. Foss. Vien.*, p. 38, pl. 1, figs. 34, 35.
- PROBOSCIDEA, *Reuss*, 1850. *Haiding. Nat. Abhand.*, vol. iv, p. 23, pl. 2, fig. 6.
- VENUSTA, *Reuss*, 1850. *Denks. Akad. Wien.*, vol. i, pl. 46, fig. 5.
- LAGENA WILLIAMSONI (?), *Harvey and Bailey*, 1853. *Proc. Acad. Philadelphia*, vol. vi, p. 431.
- DENTALINA INFLATA, *Reuss*, 1855. *Zeitsch. Deutsch. Geol. Ges.*, vol. vii, p. 262, pl. 8, figs. 2—4.
- NODOSARIA BADENENSIS, var. ACULEATA, *Egger*, 1857. *Foram. Miocän-Schicht. Nieder-Bayern*, p. 52, pl. 11, figs. 17—21.

- NODOSARIA SIMONIANA, *Terquem*, 1858. *Mém. Acad. Metz*, Année xxxix, p. 587, pl. 1, figs. 4 *a, b*.
 — PRIMA, *Id.* *Ib.*, p. 589, pl. 1, figs. 6 *a, b*.
 — RADICULA, *Williamson*, 1858. *Rec. For. Gt. Br.*, p. 15, pl. 2, figs. 36—38.
 — NANA, *Reuss*, 1860. *Sitz. Akad. Wien.*, vol. xl, p. 35, pl. 1, fig. 6.
 — LONGICAUDA, *Parker and Jones*, 1860. *Quart. Journ. Geol. Soc.*, vol. xvi, p. 302; 1862, in *Carpenter's Introd., Append.*, p. 310.
 — — *Brady*, 1864. *Trans. Linn. Soc.*, vol. xxiv, p. 473.
 — SCALARIS, *P., J., and Brady*, 1865. *Ann. Nat. Hist.*, 3rd ser., vol. xv, p. 227.
 — — *Parker and Jones*, 1865. *Phil. Trans.*, vol. clv, p. 340, pl. 16, figs. 2 *a—c*; pl. 18, fig. 13.
 — ANNULATA, *Costa* (n. d.) *Foram. Foss. Terz. Messin.*, p. 13, pl. 1, fig. 16.

Characters.—Shell straight, generally composed of from two to five chambers. Second chamber often smaller than the first, otherwise each succeeding chamber larger than that immediately preceding it. Chambers ventricose. Ornamentation, a number of neat parallel costæ, generally continuous from end to end of the shell. Pseudopodial aperture at the summit of the elongated neck of the ultimate segment, and often lipped.

This is a common variety of *Nodosaria*, of altogether feebler growth, and having fewer chambers, than *N. raphanius*; the shell, too, is thinner and more hyaline. The specimen from which our figure is taken is a very small, two-chambered, unique individual from the Bridlington Crag, in Mr. H. C. Sorby's collection.

N. scalaris is the most common recent *Nodosaria*, and it is found sparingly in all temperate and tropical seas. Its geological distribution is similar to that of *N. raphanus*, being known in the Secondary formations, and occurring in various strata up to the later Tertiary clays, in which it is not uncommon.

Subgenus—DENTALINA, *D'Orbigny*.

ORTHOCERAS, *Gualtieri, Martini*.

NAUTILUS, *Linné, Schröter, Batsch, Gmelin, Turton, Montagu, Maton and Rackett, Pennant, Dillwyn, Wodarch*.

ORTHOCERA, *Lamarck, Brown, Fleming, Hanley, Thorpe*.

NODOSARIA, *Lamarck, DeFrance, D'Orbigny, Brown, Nilsson, Hisinger, Münster and Roemer, Michelotti, Parker and Jones, Reuss, Carpenter*.

DENTALINA, *D'Orbigny, Risso, Bronn, Ehrenberg, Macgillivray, S. Wood and Morris, Reuss, Czjzek, Alth, Cornuel, Jones, Bayley, Eichwald, Schultze, Bornemann, Parker and Jones, Williamson, Terquem, Neuegeboren, Karrer, Brady, Stache*.

General characters.—Shell awl-shaped, subcylindrical, tapering, curved; composed

of several chambers in a linear series; the primordial segment often very small. Septal lines either straight or oblique; usually constricted, occasionally level with the surface. Aperture terminal, often pouting, and nearly always excentric. *Dentalina* is not separable from *Nodosaria*, *Vaginulina*, and *Marginulina*, except artificially; for they all pass one into the other by numerous gradations.

DENTALINA OBLIQUA, *Linné*. Plate I, fig. 9.

- Orthoceras minimum*, &c., *Gualtieri*, 1742. Index Test., pl. 19, fig. NN.
NAUTILUS OBLIQUUS, *Linné*, 1767. Syst. Nat., ed. 12, p. 1163, No. 281.
 — *JUGOSUS*, *Montagu*, 1803. Test. Brit., vol. i, p. 198, pl. 14, fig. 4.
NODOSARIA SULCATA, *Nilsson*, 1825. Trans. Acad. Stockholm, p. 341; 1827, Petref. Suecana, p. 8, pl. 9, fig. 19; *Hisinger*, Leth. Suec., 1837, p. 33, pl. 10, fig. 4 (few-ribbed).
 — *ELEGANS*, *Münster*, 1838. Neues Jahrb., 1838, p. 382, pl. 3, fig. 1.
 — (*DENTALINA*) *SULCATA*, *D'Orb.*, 1840. Mém. Soc. Géol. Fr., vol. iv, p. 15, pl. 1, figs. 10—13.
 — — *MULTICOSTATA*, *Id.* Ib., p. 15, pl. 1, figs. 14, 15 (many-ribbed).
DENTALINA JUGOSA, *S. Wood*, 1843. Morris's Cat. Brit. Foss., p. 61.
NODOSARIA ZIPPEI (parte), *Reuss*, 1845. Verst. Böhm. Kreid. I, p. 25, pl. 8, fig. 1.
 — *AFFINIS*, *Id.* Ib., pl. 13, fig. 16.
 — *COSTELLATA*, *Id.* Ib., fig. 18.
DENTALINA URNULA, *D'Orb.*, 1846. For. Foss. Vien., p. 54, pl. 2, figs. 31, 32 (*Dentalina* form of *Nodosaria scalaris*).
 — *ELEGANTISSIMA*, *Id.* Ib., p. 55, pl. 2, figs. 33—35 (few-ribbed).
 — *BIFURCATA*, *Id.* Ib., p. 56, pl. 2, fig. 38, 39.
 — *ACUTA*, *Id.* Ib., figs. 40—43.
 — *PRIMÆVA*, *D'Orb.*, 1850. Prod. Paléont., vol. i, p. 242, No. 260.
 — *SEMINUDA*, *Reuss*, 1850. Denks. Akad. Wien., vol. i, p. 368, pl. 46, fig. 9.
 — *BIFURCATA*, *Id.* Ib., fig. 10.
 — *ACUTICOSTA*, *Id.* Ib., p. 369, pl. 16, fig. 11.
 — *KINGII*, *Jones*, 1850. King's Monogr. Permian Foss., p. 17, pl. 6, figs. 2, 3.
 — *PUNGENS*, *Reuss*, 1851. Zeitsch. Deutsch. Geol. Ges., vol. iii, p. 63, pl. 3, fig. 13.
 — *MUENSTERI*, *Reuss*, 1855. Sitz. Akad. Wien., vol. xviii, p. 31, pl. 1, fig. 8.
 — *LONGICAUDA*, *Id.* Zeitsch. Deutsch. Geol. Gesell., vol. vii, p. 267, pl. 8, fig. 12.
 — *ACUTISSIMA*, *Id.* Ib., pl. 8, fig. 13.
 — *STEENSTRUPI*, *Id.* Ib., p. 268, pl. 8, fig. 14 a.
 — *SULCATA*, *Id.* Ib., fig. 14 b.
 — *BALTICA*, *Id.* Ib., p. 269, pl. 8, fig. 15.

- DENTALINA ACUTICOSTA, D. BIFURCATA, D. MULTILINEATA, *Bornemann*, 1855. *Zeits. Deut. Geol. Ges.*, vol. vii, p. 325, pl. 13, figs. 9—12.
- CREBICOSTATA, *Neugeboren*, 1856. *Denks. Akad. Wissen. Math.-Natur. Cl.*, vol. xii, p. 90, pl. 4, figs. 12, 13.
- LAMARCKI, *Id.* *Ib.*, p. 91, pl. 4, figs. 16 *a*, 16 *b*.
- PRIMÆVA, *Terquem*, 1858. *Mém. Acad. Imp. Metz.*, 39 année, p. 603, pl. 2, figs. 12 *a*, *b*.
- SUBARCUATA, var. JUGOSA (parte), *Williamson*, 1858. *Rec. For. Gt. Br.*, p. 20, pl. 2, fig. 42.
- NODOSARIA RAPHANUS, var. OBLIQUA, *Parker and Jones*, 1859. *Ann. Nat. Hist.*, ser. 3, vol. iv, p. 351.
- DENTALINA MARCKI, *Reuss*, 1860. *Sitz. Akad. Wien.*, vol. xl, p. 188, pl. 2, fig. 7.
- POLYPHRAGMA, *Id.* *Ib.*, p. 189, pl. 3, fig. 1.
- KONINCKI, D. MICROPTYCHA, D. ARCUATA, *Id.* *Ib.*, vol. xlii, p. 356, &c., figs. 3—5.
- CONFLUENS, *Reuss*, 1861. *Ib.*, vol. xliv, p. 335, pl. 7, fig. 5.
- NODOSARIA SIPHUNCULOIDES, *Costa* (n. d.). *Foram. Foss. Marne Terziar. Messina*, p. 9, pl. 1, fig. 27.
- DENTALINA MARTINI, *Terquem*, 1862. *Mém. Acad. Imp. Metz.*, 43 année, p. 454, pl. 6, fig. 14.
- ACICULA, *Parker and Jones*, 1862. In *Carpenter's Introd.*, Append., p. 310.
- LINEATA, *Reuss*, 1864. *Sitz. Akad. Wiss. Math.-Natur. Cl.*, vol. l, 1 Abth., p. 22, pl. 4, fig. 11.
- ACICULA, *Brady*, 1864. *Trans. Linn. Soc.*, vol. xxiv, p. 473.
- SCHWARZII, *Karrer*, 1864. *Sitzung. Akad. Wien.*, vol. l, 1 Abtheil., p. 15, pl. 1, fig. 5.
- OBSCURA, *Stache*, 1865. *Novara-Exped.*, *Geol. Theil*, part 2, p. 208, pl. 22, fig. 37.
- NODOSARIA (DENTALINA) PUNGENS, *Reuss*, 1866. *Denks. Akad. Wissen. Math.-Natur. Cl.*, vol. xxv, p. 19, pl. 2, fig. 16.

Characters.—Shell elongated, arcuate, tapering; composed of numerous (six to fifteen) chambers, which are subcylindrical and more or less ventricose, with the septal lines generally constricted, and the surface covered with riblets, varying in number and size in different specimens. Length $\frac{1}{10}$ th to $\frac{4}{10}$ ths inch.

Dentalina obliqua may be regarded as the curved form of *Nodosaria raphanistrum*. Like the latter, it has usually a large number of chambers, and it is covered with similar parallel longitudinal ribs, and under favorable circumstances it attains to similarly large dimensions, the only difference being a more or less curved mode of growth. Some specimens seem rather to be the curved forms of *N. raphanus*; but there is little or no real difference. The straight tapering variety of *N. raphanistrum* is *N. acicula*, Lamarck.

Mr. Searles Wood's specimens from Sutton are fine and numerous; but we have not obtained it from other Crag beds. It is not an uncommon form in the various Secondary

and Tertiary fossiliferous clays. It occurs in the Lias, in the Chalk, and in the more recent formations of countries bordering on the Mediterranean.

Living specimens have been found on our own coast, in the Mediterranean (320 fathoms), and in the Indian Ocean (1120 fathoms); but it can scarcely be looked upon as a common recent species.

DENTALINA OBLIQUESTRIATA, *Reuss*. Plate I, fig. 19.

DENTALINA MATUTINA, *D'Orb.*, 1850. *Prodrome Paléont.*, p. 242, No. 259.

— OBLIQUESTRIATA, *Reuss*, 1851. *Zeitsch. Deutsch. Geol. Gesell.*, vol. iii, p. 63, pl. 3, figs. 11, 12.

— GEINITZIANA, *Neugeboren*, 1856. *Denks. Akad. Wien. Math.-Natur. Cl.*, vol. xii, p. 91, pl. 4, fig. 15.

— — *Terquem*, 1858. *Mém. Acad. Imp. Metz.*, 39 année, p. 602, figs. 11 a, b.

— DIVERGENS, *Reuss*, 1864. *Sitz. Akad. Wissen. Math.-Natur. Cl.*, vol. I, 1 Abtheil., p. 22, pl. 4, fig. 10.

Characters.—The same as those of *D. obliqua*, except that the striæ, which in *D. obliqua* are parallel to the longitudinal axis of the shell, take an oblique direction in *D. obliquistriata*. Length $\frac{1}{10}$ th inch.

The artificial division which it has been necessary to adopt in reference to the nomenclature of the *Nodosarinæ* renders the trivial name given by Prof. Reuss applicable as a subvarietal distinction to the curved (Dentaline) specimens with oblique striæ, although as early as 1791 straight (Nodosarian) forms similarly marked were figured by Batsch with the specific name "*obliquata*." The straight and the curved specimens have the same kind of costation, and are not really distinct specifically, much less generically.

There have been specimens figured, under various names, in which the oblique striæ are interrupted and partial (like those on the congeneric *Vaginulinæ* shown by our Plate I, fig. 10).

Occasional specimens of this obliquely ribbed form are met with wherever *Nodosarinæ* are abundant; but it is nowhere common, and we are not aware that it has been found in a recent condition.

DENTALINA COMMUNIS, *D'Orbigny*.

Under the name of *Nodosaria* (*Dentalina*) *communis* D'Orbigny has placed two varieties of smooth, tapering, curved *Nodosariæ*, one having *straight* and the other *inclined* septa. Both of these conditions (the septal planes being in one case at right angles to the axis of the shell, and in the other oblique) occur together in very many specimens of such *Dentalinæ*, and therefore can be accepted only as artificial means of distinction. Moreover, the relative length and convexity of the segments are extremely variable, even in one and the same specimen; and the length, also, and curvature of the shell, and its departure from the cylindrical form, are all unstable characters. It results that all these varieties (almost as numerous as the individuals) can be grouped either under "*Nodosaria dentalina*" of Lamarek, or the better known name "*Dentalina communis*," D'Orbigny. For convenience, we may keep the oblique-chambered specimens separate from the others when it preponderates over the other character.

The modifications of the *Dentalinæ* having straight septa are more numerous than the others, as the latter, or oblique forms, soon become more definitely characterised as "*Vaginulinæ*" and "*Marginulinæ*."

There are, however, other varieties of smooth *Dentalinæ*, many specimens having globose chambers (*D. radicularis*, Münster, &c.), and others having swollen but long segments (*D. globifera*, Batsch, &c.).

These smooth *Dentalinæ* are really tapering and curved sub-varieties of *Nodosaria radicula*; the ornamented individuals belonging to *N. raphanus*; and the obliquity of the segments and departure from axial symmetry culminating in the closely coiled and discoidal *Cristellarinæ*.

Among the numerous Dentaline sub-varieties of *Nodosaria raphanus* (*Dentalina obliqua*, Linn., being the first in order) every modification of *N. raphanus* has its Dentaline representative, whether the riblets be general or partial, few or many, coarse or fine, straight or oblique, continuous or interrupted, obsolete or replaced by spines or granules. So also there are Vaginuline, Marginuline, Cristellarian, Frondicularian, and other modifications, respectively smooth (after the habit of *N. radicula* and its congeners), or ornamented (after any of the patterns adopted by *N. raphanus* in its variations). As *Marginulina raphanus* is the central form of all these modifications of one type, we have chosen it (as *Nodosarina raphanus*, typica) as the zoological representative of the group.

It is inconvenient at present to construct a scheme of the alliances of the chief Nodosarine forms; and even for the *Nodosariæ* alone it would be almost a vain labour to attempt it, as they all mutually graduate one into the other—*Glandinulinæ*, *Lingulinæ*, *Dentalinæ*, *Vaginulinæ*, *Marginulinæ*, &c., having full participation in all the characters

of *Nodosariæ*, and hybrid individuals being almost as common as any of the so-called typical varieties.

Dentalinæ with a central aperture (Pl. I, fig. 9, for instance) are merely bent *Nodosariæ*. When the aperture is excentric, and the shell is tapering and curved, we have a "*Dentalina*" if it be round in transverse section, and "*Vaginulina*" if it be compressed. But often a shell is Vaginuline (compressed) in its early growth and Dentaline when old, and this is the case with fig. 10, a Dentaline form of *Vaginulina linearis*. The compressed forms are often straight, and therefore most of the *Vaginulinæ* are straight rather than curved. If in a compressed shell, stouter than the tapering forms, and commencing with a relatively larger segment, or with coiled segments, the septal apertures follow the convex margin, we have a "*Marginulina*" (fig. 36); and a stout Nodosarian shell, circular in section, and with its septal apertures marginal, is also a "*Marginulina*" (Pl. I, fig. 21). If, however, these straight, stout, oblique-chambered *Nodosariæ*, with marginal aperture, be much compressed at the edges (being then acute-oval in transverse section), they pass as *Vaginulinæ* (Pl. IV, fig. 9).

It is very difficult, therefore, to place all straight Nodosarian specimens definitely in one or other of these groups, which are quite artificial; for Marginuline and Dentaline forms of *Nodosaria raphanus* (compare Pl. I, figs. 4, 9, 19, 21) and similar conditions of *N. radricula* abound, wandering from *Glandulinæ* and *Lingulinæ* to *Cristellariæ*, *Flabellinæ*, &c., without any real zoological distinction.

DENTALINA COMMUNIS, D'Orbigny.

a. *With straight septal planes.* Plate I, figs. 13—18, 20; Plate IV, fig. 10.

- NAUTILUS (ORTHOCERAS) LEGUMINIFORMIS (parte), *Batsch*, 1791. *Conch. Seesand.*, pl. 3, fig. 8 b.
- RECTUS, *Montagu*, 1808. *Test. Brit. Supplem.*, p. 82, pl. 19, figs. 4, 4', 7.
- NODOSARIA DENTALINA, *Lamarck*, 1822. *Anim. sans Vert.*, vol. vii, p. 596, No. 2.
- LÆVIGATA, *Nilsson*, 1825. *Act. Acad. Holm.*, 1825, p. 342; 1827, *Petrif. Suec.*, p. 8, pl. 20, fig. 20.
- (DENTALINA) COMMUNIS, *D'Orb.*, 1826. *Ann. Sc. Nat.*, vol. vii, p. 254, No. 35; after *Soldani*, *Testac.*, vol. ii, pl. 105, fig. o. (Montagu's *N. rectus* is catalogued by D'Orbigny as var. a of this species.)
- LÆVIGATA, *Hisinger*, 1837. *Lethæa Suecica*, p. 33.
- (DENTALINA) GRACILIS, *D'Orb.*, 1840. *Mém. Soc. Géol. France*, vol. iv, p. 14, pl. 3, fig. 5.
- — NODOSA, *Id.* *Ib.*, figs. 6, 7.
- — LORNEIANA, *Id.* *Ib.*, figs. 8, 9.
- LINEARIS, *Roemer*, 1840. *Verst. Nordd. Kreid.*, p. 95, pl. 15, fig. 5.

- DENTALINA CLAVA, D. ATTENUATA, *S. Wood*, 1843. *Morris's Catal. Brit. Foss.*, p. 61.
- NODOSARIA LORNEIANA, *Reuss*, 1845. *Verst. Böhm. Kreid.*, part 1, p. 27, pl. 8, fig. 5.
- GRACILIS, *Id.* *Ib.*, fig. 6.
- ANNULATA, *Id.* *Ib.*, pl. 13, fig. 21.
- DENTALINA OLIGOSTEGIA, *Id.* *Ib.*, p. 29, pl. 13, figs. 19, 20; 1851, Haidinger. *Abhandl.*, vol. iv, p. 19, pl. 2, fig. 10.
- ELEGANS, *D'Orb.*, 1846. *For. Foss. Vien.*, p. 45, pl. 1, figs. 52—56.
- PAUPERATA, *Id.* *Ib.*, p. 46, pl. 1, figs. 57, 58.
- CONSOBRINA, *Id.* *Ib.*, pl. 2, figs. 1—3.
- BOUEANA, *Id.* *Ib.*, p. 47, pl. 2, figs. 4—6.
- VERNEUILII, *Id.* *Ib.*, p. 48, pl. 2, figs. 7, 8.
- BREVIS, *Id.* *Ib.*, figs. 9, 10.
- PUNCTATA, *Id.* *Ib.*, p. 49, pl. 2, figs. 14, 15.
- *Williamson*, 1847. *Microp. Obj. Levant*, p. 78, pl. 4, figs. 70, 72.
- INERMIS, *Czjzek*, 1848. *Haidinger's Naturw. Abhandl.*, vol. ii, p. 138, pl. 12, figs. 3—7.
- MARGINULINA CONTRARIA, *Id.* *Ib.*, p. 140, pl. 12, figs. 17—20.
- DENTALINA MONILE, *Cornuel*, 1848. *Mém. Soc. Géol. France*, ser. 2, vol. iii, p. 247, pl. 1, fig. 18.
- ANTENNA, D. INTERMEDIA, D. CHRYSALEIS, *Id.* *Ib.*, figs. 19—21.
- TRICHOSTOMA, *Reuss*, 1850. *Denksch. k. k. Akad. Wiss. Wien.*, vol. i, pl. 46, fig. 6.
- TERQUEMI, *D'Orb.*, 1850. *Prodrôme Pal.*, vol. i, p. 242, No. 257.
- ANNULATA, *Alth.*, 1850. *Haidinger's Abhandl.*, vol. iii, p. 270, pl. 13, fig. 29.
- PERMIANA, *Jones*, 1850. *King's Monogr. Perm. Foss.*, p. 17, pl. 6, fig. 1.
- SUBNODOSA, *Reuss*, 1851. *Haidinger's Naturw. Abhandl.*, vol. iv, p. 18, pl. 2, fig. 9.
- MARGINULOIDES, *Id.* *Ib.*, p. 19, pl. 2, fig. 12.
- ANNULATA, *Id.* *Ib.*, fig. 13.
- LEGUMEN, *Id.* *Ib.*, fig. 14.
- MUTABILIS, *Bailey*, 1851. *Smithsonian Contrib.*, 1861, vol. ii, pl. 1, fig. 7.
- DISPAR, D. ACUTICAUDA, D. EMACIATA, *Reuss*, 1851. *Zeitsch. Deutsch. Geol. Ges.*, vol. iii, p. 52, pl. 3, figs. 7—9.
- OBTUSATA, *Id.* *Ib.*, p. 151, pl. 8, fig. 1.
- ENSIS, D. IRREGULARIS, *Eichwald*, 1852. *Lethæa Rossica*, part 1, p. 9, pl. 1, figs. 6 a, 6 b.
- PLEBEIA, D. MEGALOPOLITANA, D. TENUICOLLIS, *Reuss*, 1855. *Zeitsch. Deutsch. Geol. Ges.*, vol. vii, p. 267, pl. 8, figs. 9—11.
- CONSOBRINA, *Bornemann*, 1855. *Ib.*, p. 323, pl. 13, figs. 1—4.
- ELEGANS, D. PAUPERATA, D. VERNEUILII, *Id.* *Ib.*, figs. 6—8.
- MARGINULINA TENUIS, *Id.* *Ib.*, p. 14.
- DENTALINA REUSSI, *Neuegeboren*, 1856. *Denks. Akad. Wiss.*, vol. xii, p. 85, pl. 3, figs. 6, 7.
- PYGMÆA, *Id.* *Ib.*, fig. 9.
- HAIDINGERI, *Id.* *Ib.*, fig. 12.
- CONSOBRINA, *Egger*, 1857. *For. Mioc. Ortenburg*, p. 54, pl. 11, figs. 22, 23.
- TERQUEMI *Terquem*, 1858. *Mém. Acad. Imp. Metz*, 39 année, p. 596, pl. 2, figs. 1, 23 (= *D. pauperata*, *D'O.*).

- DENTALINA OBSCURA, *Terquem*, 1858. Mém. Acad. Imp. Metz, 39 année, p. 597, pl. 2, fig. 2 (= *D. pauperata*, D'O.).
- ACUMINATA, D. CYLINDROIDES, D. COGNATA, D. SUBRECTA, *Reuss*, 1860. Sitzungs. Akad. Wien., vol. xl, p. 37, &c., pl. 1, figs. 7—10.
- TENUICAUDATA, D. COMMUTATA, D. DISTINCTA, D. STRANGULATA, *Id.* *Ib.*, pl. 2, figs. 3—6.
- CATENULA, D. DISCREPANS, D. FILIFORMIS, D. PUGIUNCULUS, *Id.* *Ib.*, pl. 3, figs. 6—9.
- NODOSARIA DENTALINA, *Parker and Jones*. Ann. Nat. Hist., ser. 3, vol. vi, p. 39.
- DENTALINA PAUPERATA, *Id.* Quart. Journ. Geol. Soc., vol. xvi, p. 457, pl. 19, fig. 22.
- NUDA, *Reuss*, 1862. Sitzungs. Akad. Wiss., vol. xlvi, p. 38, pl. 2, figs. 8, 9.
- PSEUDOCRYSALIS, *Id.* *Ib.*, p. 40, pl. 2, fig. 12.
- HILSEANA, *Id.* *Ib.*, p. 41, pl. 2, fig. 14.
- LINEARIS, *Id.* *Ib.*, p. 42, pl. 2, fig. 15.
- CYLINDROIDES, *Id.* *Ib.*, fig. 16.
- LAMILIFERA, *Id.* *Ib.*, fig. 17.
- BENNINGSENI, D. INDIFFERENS, *Reuss*, 1863. Sitzungs. Akad. Wien., vol. xlviii, 1 Abth., p. 44, pl. 2, figs. 14—16.
- CONSOBRINA, *Id.* *Ib.*, figs. 19—23.
- ACUTICAUDA, *Id.* *Ib.*, p. 45, pl. 3, fig. 26.
- BUCCULENTA, D. DETORNATA, *Schwager*, 1864. In Dittmar's Die Contortazone, pp. 404, 406, pl. 3, figs. 8, 9.
- COLLISA, *Id.* *Ib.*, p. 405, pl. 3, fig. 10.
- MARGINULINA INCERTA, *Id.* *Ib.*, p. 407, pl. 3, fig. 13.
- DENTALINA ÆQUALIS, *Karrer*, 1864. Novara-Exped., Geol. Theil, vol. i, part 2, p. 74, pl. 16, fig. 1.
- NODOSARIA (DENTALINA) PAUPERATA, *Parker and Jones*, 1865. Phil. Trans., vol. clv, p. 342, pl. 13, figs. 8, 9.
- — CONSOBRINA, *Id.* *Ib.*, pl. 16, fig. 3.
- DENTALINA VAGINA, *Stache*, 1865. Novara-Exped., Geol. Theil, vol. i, part 2, p. 206, pl. 22, fig. 34.
- NODOSARIA INARTICULATA, N. TENUICOLLIS, *Reuss*, 1865. Sitzungs. Akad. Wien., vol. lii, 1 Abtheil., p. 7, pl. 1, figs. 5, 6.
- (DENTALINA) GRANDIS, *Reuss*, 1866. Deutsch. Acad. Wien., vol. xxv, p. 15, pl. 1, figs. 26—28.
- — PYGMÆA (*Neueg.*), *Id.* *Ib.*, p. 17, pl. 2, fig. 9.
- — ABNORMIS, *Id.* *Ib.*, p. 18, pl. 4, fig. 10.
- — ACUTICAUDA, *Id.* *Ib.*, p. 17, pl. 2, fig. 11.
- — CONSOBRINA, var. EMACIATA, *Id.* *Ib.*, p. 16, pl. 2, figs. 12, 13.
- — VERMICULUM, *Id.* *Ib.*, p. 17, pl. 2, figs. 14, 15.
- — APPROXIMATA, *Id.* *Ib.*, p. 18, pl. 2, fig. 22.

β. With oblique septa.

- NODOSARIA (DENTALINA) COMMUNIS, *D'Orb.*, 1826. *Ann. Sc. Nat.*, vol. vii, p. 254, No. 35; 1840, *Mém. Soc. Géol. France*, vol. iv, p. 13, pl. 1, fig. 4.
- — — OBLIQUA, *Id.* Ib., No. 36; Modèle No. 5.
- — — ARCUATA, *Id.* Ib., No. 38.
- — — CARINATA, *Id.* Ib., p. 255, No. 39.
- DENTALINA CINGULATA, *Czjzek*, 1848. *Haidinger's Naturwiss. Abhandl.*, vol. ii, pl. 12, figs. 8, 9.
- FERSTLIANA, *Id.* Ib., figs. 10—13.
- ACUS, *Reuss*, 1851. *Haid. Nat. Abhandl.*, vol. iv, pl. 2, fig. 15.
- MARGINULINA ENSIS, M. ELONGATA, M. APICULATA,¹ *Id.* Ib., figs. 16—18.
- NODOSARIA COMMUNIS, *Reuss*, 1845. *Verst. Böhm. Kreid.*, part 1, p. 28, pl. 12, fig. 21.
- (et VAGINULINA) LEGUMEN, *Id.* Ib., p. 64, pl. 13, figs. 23, 24.
- VAGINULINA BADENENSIS, *D'Orb.*, 1846. *For. Foss. Vien.*, p. 65, pl. 3, figs. 6—8.
- DENTALINA GLOBULIGERA, *Neuegeboren*, 1856. *Denks. Akad. Wiss.*, vol. xii, p. 81, pl. 2, fig. 10.
- CONFERTA, *Id.* Ib., fig. 11.
- HAUERI, *Id.* Ib., fig. 12.
- ROEMERI, *Id.* Ib., p. 82, pl. 2, figs. 13—17.
- ORBIGNYANA, *Id.* Ib., pl. 3, figs. 1—3.
- SUBTILIS, *Id.* Ib., p. 83, pl. 3, fig. 4.
- PARTSCHII, *Id.* Ib., fig. 5.
- MUCRONATA, *Id.* Ib., p. 85, pl. 3, figs. 8—11.
- SUBULATA, *Id.* Ib., fig. 13.
- NODOSARIA (DENTALINA) COMMUNIS, var., *Parker and Jones*. *Ann. Nat. Hist.*, 2nd ser., 1864, vol. xix, p. 282, pl. 11, fig. 1; 1865, *Phil. Trans.*, vol. clv, p. 342, pl. 13, fig. 10.
- DENTALINA VETUSTA, *Terquem*, 1858. *Mém. Acad. Metz*, 39 année, p. 598, pl. 2, fig. 4.
- TORTA, *Id.* Ib., p. 599, pl. 2, fig. 6.
- SUBARCUATA, *Williamson*, 1858. *Rec. Fos. Gr. Brit.*, p. 18, pl. 2, figs. 40, 41.
- COMMUNIS, *Eley*, 1859. *Geology in the Garden*, p. 199, pl. 4, fig. 21, and pl. 6, fig. 33.
- BREVIS, *Parker and Jones*, 1860. *Quart. Journ. Geol. Soc.*, vol. xvi, p. 457, pl. 19, figs. 23, 24.
- COMMUNIS, *Id.* Ib., figs. 25, 26.
- VAGINULINA LEGUMEN,² *Id.* Ib., figs. 27, 28.
- DENTALINA INTERMEDIA, *Reuss*, 1860. *Sitz. Akad. Wien.*, vol. xl, p. 42, pl. 8, fig. 8.

¹ These are quoted to show the extremely slight difference between Dentaline and Marguline *Nodosarinæ*.

² Quoted to show how inseparable all these forms really are.

- DENTALINA LEGUMEN, *Reuss*, 1860. Sitz. Akad. Wien., vol. xl, p. 43, pl. 9, fig. 5.
 — COLLIGATA, *Reuss*, 1861. Sitzungs. Ak. Wien., vol. xlv, 1 Abth., p. 334, pl. 7, fig. 4.
 — NANA, *Reuss*, 1862. Ib., vol. xlvi, p. 39, pl. 2, figs. 10, 18.
 — SILIQUA, *Id.* Ib., p. 40, pl. 2, fig. 11.
 — DEFLEXA, *Id.* Ib., p. 43, pl. 2, fig. 19.
 — BOETTCHERI, *Reuss*, 1863. Ib., vol. xlviii, 1 Abtheil., p. 44, pl. 2, fig. 17.
 — INORNATA, *Id.* Ib., p. 45, pl. 2, fig. 18.
 — ABNORMIS, D. OBLIQUATA, *Id.* Ib., p. 46, pl. 2, figs. 24, 25.
 — MARGINATA, D. OBLIQUESUTURATA, *Stache*, 1865. Novara-Exped., Geol. Theil, vol. i, part 2, p. 207, pl. 22, figs. 35, 36.
 MARGINULINA DURACINA, *Id.* Ib., p. 211, pl. 22, fig. 42.

Characters.—Shell elongated, tapering, more or less curved; consisting of numerous segments, generally somewhat ventricose. Primordial segment sometimes larger than the second, and either rounded or pointed at its free extremity. The terminal pseudopodial aperture more or less excentric, sometimes pouting on a prolonged neck, but more commonly a simple orifice, surrounded by radiating grooves. Septal lines often more or less oblique, and generally constricted. Length $\frac{1}{20}$ th to $\frac{1}{8}$ th inch.

Although it may be thought that the list of synonyms we have quoted has been carried to an excessive length, we may be allowed to state that it is by no means an exhaustive catalogue. We have carefully avoided doubtful figures; and in our references to the papers of foreign authors, whenever there has seemed to be anything like a sufficiently distinct character on which to found a sub-variety, we have omitted the name from our table. It is only this desire to be on the safe side in massing previously described "species," that has prompted us to admit such sub-varietal forms as *D. pauperata* and *D. brevis* to separate mention.

Dentalina communis is an extremely common variety wherever Nodosarian forms occur in the clays of the Secondary formations, but usually it is of small size. It is larger in the Gault than in the Jurassic clays; still larger in the Chalk-marl and Chalk; and in the Maestricht Chalk it is large, as well as in the Tertiary beds that yield *Nodosarinæ*, being very finely developed in the Sub-Apennine clays. Older than the Secondary deposits, however, it is found in the Permian limestones of England and Germany.

The Crag specimens in Mr. Searles Wood's collection from Sutton are numerous, exceedingly large, and correspond to *D. pauperata* and such like modifications of group *a*.

The Bridlington Crag has supplied a specimen corresponding to D'Orbigny's *D. brevis*, of the same group *a*.

D. communis is a common recent species; indeed, its geographical range is as extraordinary as the extent of its geological distribution. It is found in every latitude from

the Arctic circle to the equator. It occurs in many sandy shore-deposits; but its favorite habitat is mud at 50—100 fathoms, and is continually met with in the deepest soundings, although never abundant there, and generally small.

DENTALINA COMMUNIS, *D'Orbigny*.

Sub-variety—*D. PAUPERATA*, *D'Orb.* (see above, p. 59).

Characters.—Shell elongate, sub-cylindrical, composed of many chambers. The early chambers sometimes cylindrical, the others more or less ventricose. Shell often irregular and unsymmetrical. Length $\frac{1}{12}$ th to $\frac{1}{8}$ th inch.

Dentalina pauperata is a mere name of convenience for certain forms of *Dentalina communis*, in which the chambers have a compact style of growth, the septal lines being sometimes quite obscured. Large specimens were not uncommon in the Crag beds at Sutton worked by Mr. S. Wood.

We find *D. pauperata* in marls of the Lias, in the Chalk, in the various fossiliferous Tertiary clays, and occasionally recent where other *Dentalinæ* abound.

DENTALINA COMMUNIS, *D'Orbigny*.

Sub-variety—*D. BREVIS*, *D'Orb.* (see above, p. 59).

Characters.—Shell stout, sub-cylindrical, consisting of few (three to five) rather ventricose and more or less compact chambers. Length $\frac{1}{10}$ th inch.

Of the poorly grown specimens of unstriated *Dentalinæ* (or curved *Nodosaria radicular*), the stunted few-chambered forms may be conveniently taken together under *D'Orbigny's* designation *D. brevis*. The characters are of little interest or significance, and it is so associated in distribution with the sub-typical *D. communis* as not to require separate treatment. Our figured specimen is from the Bridlington Crag.

Subgenus—VAGINULINA, *D'Orbigny*.

ORTHOCERAS, *Gualtier, Batsch, Hanley*.

NAUTILUS, *Linné, Martini, Schroeter, Gmelin, Montagu, Turton, Maton and Rackett, Dillwyn, W. Wood*.

ORTHOCERA, *Lamarck, Blainville, Fleming, Thorpe.*

VAGINULINA, *D'Orbigny, Roemer, Ehrenberg, Macgillivray, Bronn, Morris, Reuss, Parker and Jones, Terquem, Bornemann, Neuegeboren, Cornuel, Karrer, Brady, Seguenza, &c.*

DENTALINA (in part), *Macgillivray, Williamson.*

SPIRALINA, *Brown.*

Characters.—Shell elongate, tapering, straight or arcuate, compressed; composed of several oblique segments, arranged in a linear series; slightly or not at all constricted at the septal lines. Aperture marginal.

Vaginulina proper has a compressed shell, but some specimens have the earlier segments compressed and the later chambers vesicular, thus comprising Dentaline or Marginuline characters, as the case may be. In a Nodosarian shell with oblique chambers, if there be no compression, the shell is a *Marginulina* if stout, and a *Dentalina* if tapering. If commencing with an inclination to be spiral, the shell is a *Marginulina* if stout, but a *Planularia* if much compressed, in either case pointing towards *Cristellaria*.

Vaginulinæ may have any of the ornaments found in other *Nodosarinæ*, but they usually take on, in various degrees, and either alone or combined, first, a limbation of the septal lines and of the margins, and secondly, riblets, continuous or interrupted, and usually oblique to the axis of the shell.

Vaginulina legumen, Linné, is the type of these elongate, compressed, and oblique-chambered *Nodosarinæ*. The form referred to by Linné is smooth and compact in growth, and has limbate or thickened septal lines; *Vag. elegans*, D'Orb., and *V. ligata*, Rss., are still more limbate; Batsch figures a much less compact shell, without ornament, as *Nautilus leguminiformis*; keeled individuals (limbate on the margins only) are D'Orbigny's *Vaginulina marginata* and *V. caudata*; ribbed, without limbation, *V. linearis*, Montagu, sp., being either very sparingly ornamented or ribbed all over; partly ribbed and limbate, *V. margaritifera*, Batsch; much compressed and ribbed, *V. striata*, D'Orb.—and so on.

Genus—VAGINULINA LEGUMEN, *Linné*, sp.

a. Chambers distinct, not compact, unornamented.

NAUTILUS (ORTHOCERAS) LEGUMINIFORMIS, *Batsch*, 1791. *Conch. Seesand.*, pl. 3, fig. 8a.

NODOSARIA LEGUMEN, *Reuss*, 1845. *Verst. Böhm. Kreid.*, part 1, p. 28, pl. 13, figs. 23, 24.

DENTALINA COMMUNIS (parte), *Parker and Jones*, 1860. *Quart. Journ. Geol. Soc.*, vol. xvi, p. 457, pl. 19, fig. 26.

β. Chambers compactly set on, without ornament.

- Nautilus rectus geniculis depressis*, *Walker and Jacob*, 1784. *Test. Minut.*, p. 21, pl. 1, fig. 74.
- VAGINULINA LÆVIGATA, *Roemer*, 1838. *Neues Jahr. f.* 1838, p. 383, pl. 3, fig. 11.
- ELONGATA, *Id.*, 1840. *Verst. Nordd. Kreid.*, p. 96, pl. 15, fig. 13.
- BADENENSIS, *D'Orb.*, 1846. *For. Foss. Vien.*, p. 65, pl. 3, figs. 6—8.
- LÆVIGATA (*Roem.*), *Reuss*, 1848. *Sitz. Ak. Wiss.*, vol. xviii, p. 226, pl. 1, fig. 9.
- DENTALINA LEGUMEN, *Williamson*, 1858. *Monog. Rec. Foram.*, p. 21, pl. 2, figs. 45—49.
- VAGINULINA LEGUMEN, *Parker and Jones*, 1860. *Quart. Journ. Geol. Soc.*, vol. xvi, p. 457, pl. 19, figs. 27, 28.

γ. Compact ; limbate.

- Orthoceras minutum*, &c., *Gualtier*, 1742. *Index Test.*, pl. 19, figs. p, q.
- NAUTILUS LEGUMEN, *Linn.*, 1758. *Syst. Nat.*, edit. x, p. 711, No. 248 ; 1767, ed. xii, p. 1164, No. 288.
- — *Montagu*, 1808. *Test. Brit. Suppl.*, p. 82, pl. 19, fig. 6.
- VAGINULINA — *D'Orb.*, 1826. *Ann. Sc. Nat.*, vol. vii, p. 257, No. 2.
- ELEGANS, *Id.*, 1826. *Ib.*, No. 1.
- LIGATA, *Reuss*, 1864. *Sitz. Akad. Wiss. Math.-Nat. Cl.*, vol. 1, Abth. 1, p. 23, pl. 1, fig. 11.
- RECTA, *Karrer*, 1864. *Novara-Exped.*, Abtheil. Palæont., p. 74, pl. 16, fig. 2.

δ. Compact ; limbate on the margins only.

- VAGINULINA MARGINATA, *D'Orb.*, 1826. *Ann. Sc. Nat.*, vol. vii, p. 258, No. 7.
- CAUDATA, *Id.* *Ib.*, No. 8.

ε. Compact ; limbate and ribbed.

- NAUTILUS (ORTHOCERAS) MARGARITIFERUS, *Batsch*, 1791. *Conch. Seesand.*, pl. 4, figs. 12 a—12 c.

ζ. Compact; narrow or subcylindrical; costulate.

NAUTILUS LINEARIS, *Montagu*, 1808. Test. Brit. Suppl., p. 87, pl. 30, fig. 9.

DENTALINA LEGUMEN, var. LINEARIS, *Williamson*, 1858. Monog. Rec. For., p. 21, pl. 2, figs. 46, 47.

VAGINULINA LINEARIS, *Parker and Jones*, 1865. Phil. Trans., vol. clv, p. 343, pl. 13, figs. 12, 13.

NODOSARIA (VAGINULINA?) [fragment], *Parker and Jones*, 1857. Ann. Nat. Hist., 2nd ser., vol. xix, p. 282, pl. 11, fig. 2.

η. Compact; much compressed; smooth.

PLANULARIA LONGA, *Cornuel*, 1848. Mém. Soc. Géol. Fr., 2nd ser., vol. iii, p. 253, pl. 1, figs. 38, 39.

θ. Compact; much compressed; ribbed.

VAGINULINA STRIATA, *D'Orb.*, 1826. Ann. Sc. Nat., vol. vii, p. 257, No. 3.

ι. Compact; much compressed; limbate.

VAGINULINA KOCHII, *Roemer*, 1840. Verst. Nordd. Kreid., p. 96, pl. 15, fig. 10.

κ. Compact; much compressed; limbate and ribbed.

VAGINULINA STRIGILLATA, *Reuss*, 1845. Verst. Böhm. Kreid., part 2, p. 106, pl. 24, fig. 29.

η, θ, ι, κ, constitute the group "*Citharina*," instituted by D'Orbigny (Modèle No. 115, Livr. 5; and 'Foram. Cuba,' p. xxxvii), but subsequently disused by him.

VAGINULINA LÆVIGATA, *Roemer*. Plate IV, fig. 9.

(For synonyms, see above, p. 65.)

Characters.—Shell straight or curved, more or less compressed; chambers set on compactly, smooth. Length $\frac{1}{5}$ th inch.

We do not find a published figure exactly like our specimen from the Crag of Bridlington; but we cannot allow ourselves to give it a new name merely because it is rather stouter than the common smooth *Vaginulinæ*. Were it not quite so compressed and so

acutely oval in cross section, we might regard it as a *Marginulina*, such as *M. Webbiana*, D'Orb.,¹ and *M. obliqua*, Reuss;² and, indeed, it has almost as much right to be in that group of the *Nodosarinæ* as among the *Vaginulinæ*.

VAGINULINA LINEARIS, *Montagu*. Pl. I, figs. 10—12.

(For synonyms, see above, p. 66.)

Characters.—Shell straight or bent, more or less compressed; chambers compactly set on, more or less oval in section; ornamented in a variable degree with delicate parallel riblets, mostly oblique to axis of the shell; aperture excentric. Length $\frac{1}{3}$ th inch.

Whether in the fine specimens from the Crag of Sutton (collected by Mr. S. V. Wood) we have large *Dentalinæ obliquestriatæ*, imperfectly ornamented, or *Vaginulinæ lineares*, more Nodosarian in their make than usual, it is difficult to say. We adopt the latter supposition. In many instances *Vaginulina linearis* loses its compressed shape, and takes on more inflated chambers in its further growth, becoming *Dentaline*; and such seems to have been the habit of the Sutton specimens. After all, it is clear that neither *D. obliquestriata* nor *V. linearis* are real species, and can be separately referred to only for convenience.

As *Marginulina Webbiana*, D'Orb., and *M. obliqua*, Reuss, are almost indistinguishable from *Vaginulina lævigata*, so *M. vaginella* and *M. semicostata*, Reuss,³ are Marginuline conditions of *V. linearis*; and *V. recta*, Karrer,⁴ may be said to be the Marginuline form of *V. legumen* proper.

The elegant Foraminifer illustrated by pl. 5, fig. 2, 'Sitzung. Akad. Wiss., Math.-Nat. Cl.,' vol. I, part i, 1864, and described at p. 26, *op. cit.*, by Professor Reuss, as a variety of *Flabellina ensiformis*, Münst. and Roem., represents the fully costate condition of *Vaginulina legumen*, the common specimens of var. *linearis* being only partially covered with riblets. How this *Vaginulina* passes into *Flabellina* may be seen by Reuss's figs. 23 and 24, pl. 2, 'Sitzung. Akad. Wiss.,' vol. xviii, 1855; whilst *Cristellaria gladius*, Phil., fig. 31, of the same plate, shows *Vaginulina legumen* becoming a *Cristellaria*. In fact, links between all the *Nodosarinæ* may readily be found.

As for *V. linearis*, this form of *Vaginulina* only differs from the sub-typical *V. legumen* in costation of the surface of the shell, a character of extreme variability. Many specimens only show these markings on the first two or three chambers, whilst in others they are apparent over the greater portion, and in some cases over the whole length of the

¹ 'Foram. Canaries,' 1839, p. 124, No. 4, figs. 7—11; and 'Foram. Amér. Mérid.,' p. 24, pl. 5, figs. 17, 18.

² 'Denks. Akad. Wien.,' vol. vii, 1854, p. 69, pl. 25, fig. 9.

³ 'Zeitsch. Deutsch. Geol. Gesell.,' vol. iii, 1851, p. 152, pl. 8, figs. 2, 3.

⁴ 'Novara-Expedit.,' Abth. "Palæont.," p. 74, pl. 16, fig. 2.

shell. We have never seen it so abundant as in some sands dredged in from thirty to forty fathoms, in Berwick Bay, and in that locality the finely grown *Vaginulina* were found to be almost without exception in the ribbed condition. It is impossible to distinguish the smooth, slender, depauperated forms of *Vaginulina* from *Dentalina communis*; indeed, the two varieties merge insensibly into each other, whilst the costulate *Vaginulina* are barely separable from *D. obliquestriata*.

V. linearis is not uncommon in a recent condition on our own shores, though it appears to be somewhat local in its distribution, and the same remark applies to its occurrence in seas of both colder and warmer latitudes.

In a fossil state it is less common, but it is occasionally met with in beds belonging to the Secondary and Tertiary periods.

Subgenus—MARGINULINA, D'Orbigny.

NAUTILUS, ORTHOCERAS, ORTHOCERA, CRISTELLARIA, ORTHOCERINA,
HEMICRISTELLARIA, *Auctorum*.

MARGINULINA, D'Orbigny, Cornuel, Roemer, Reuss, Neugeboren,
Bornemann, Parker, Jones, Brady, Terquem, Karrer, Costa, &c.

Characters.—Shell elongated, subcylindrical or flattened, straight or arcuate, tending to spiral mode of growth in the earlier chambers; ornamented with ribs, granules, spines, &c., as other *Nodosarina*. Aperture nearly always excentric towards or close to the convex margin of the shell.

The difficulty of defining any special groups among the Marginuline *Nodosarina* is insuperable, every character being variable, namely, the excentricity of the axis of the shell (whether amounting to spirality or simply to a curvature), the compression, and the ornamentation, which last has the same patterns as in other *Nodosarina*.

We may take the simple smooth *Marginulina* as one group; but we are baffled by the ever-varying proportions and shape among them; and, hesitating to adopt a name for every individual, we are obliged to take *M. glabra* (see further on) as a subtype, though it graduates in form into *Vaginulina*, *Dentalina*, and *Nodosaria*, on one hand, and into *Cristellaria* on the other; whilst, as to ornament, it takes on more or less of the exogenous shell-growth, thus becoming any one of the hispid, costate, limbate, or otherwise ornamented varieties.

For another subtype in our artificial grouping, we may take the ribbed *M. raphanus*, to be presently described. For another, the keeled forms *M. carinata*, D'Orb.,¹ and *M. angistoma*, Stache,² may serve. A fourth group may comprise the limbate varieties, either

¹ 'Ann. Sc. Nat.,' vol. vii, p. 259, No. 8.

² 'Novara-Expd.,' &c., pl. 22, fig. 46.

simply limbate, as *M. obliqua* and *Cristellaria Gosæ*, Reuss,¹ or granulato-limbate, as *Marginulina Wetherellii*, Jones,² and *Cristellaria decorata*, Reuss.³ A fifth series contains those which have the chamber-walls swollen or thickened by bars transverse to the axis of the shell (*M. trilobata*, D'Orb.⁴), or knobbly, as *Marginulina Hochstetteri*, Stache,⁵ and *Hemicristellaria papillata*, Stache.⁶ In others the growth of coarse granules is carried to so great an extent that they encroach on each other, leaving only irregularly reticulate fissures, or sunken lines, on the exterior, as Stache's *Hemicristellaria verrucosa*.⁷ Lastly, a group may be formed of the prickly *Marginulinæ*, with *M. hirsuta*, D'Orb.,⁸ as a centre. But all these graduate one into the other, as respects both form and ornamentation.

MARGINULINA GLABRA, D'Orbigny. Plate I, fig. 36.

MARGINULINA GLABRA, D'Orb., 1826. Ann. Sc. Nat., vol. vii, p. 259, No. 6; Modèle No. 55.

— LEVIGATA, Id. Ib., No. 10.

— LITUUS, Id. Ib., No. 11; *Soldani*, Testac., vol. ii, p. 99, pl. 106, figs. aa, bb.

— WEBBIANA, D'Orb., 1839. For. Canaries, p. 124, pl. 1 figs. 7—11; For. Amér. Mérid., p. 24, pl. 5, figs. 17, 18.

CRISTELLARIA BERTHELOTIANA, Id. Ib., p. 125, pl. 1, figs. 14, 15.

MARGINULINA COMPRESSA, D'Orb., 1840. Mém. Soc. Géol. Fr., vol. iv, p. 17, pl. 1, figs. 18, 19.

— ELONGATA, Id. Ib., figs. 20—22.

— COMMA, Roemer, 1840. Verst. Nordd. Kreid., p. 96, pl. 15, fig. 15.

— ELEGANS, S. Wood, 1843. In Morris's Cat. Brit. Foss., p. 62.

— REGULARIS, D'Orb., 1846. For. Foss. Vien., p. 68, pl. 3, figs. 9—12.

— PEDUM, Id. Ib., figs. 13, 14.

— SIMILIS, Id. Ib., p. 69, pl. 3, figs. 15, 16.

CRISTELLARIA HAUERINA, Id. Ib., p. 84, pl. 3, figs. 24, 25.

— RHOMBOIDEA, Czjzek, 1848. Haid. Abhandl., vol. ii, pl. 12, figs. 21—23.

— LISTI, Bornemann, 1854. Lias Formation, p. 40, pl. 4, fig. 28.

MARGINULINA BACHEI, Bailey, 1857. Smith's Contrib., vol. ii, 1861, art. iii, pl. 1, figs. 2—6.

¹ 'Denks. Akad. Wien.,' vol. vii (1854), pl. 25, figs. 9, 10.

² In Morris's 'Catal. Brit. Foss.,' 2nd ed., 1854, p. 37.

³ 'Zeits. Deut. Geol. Ges.,' vol. vii, 1855, pl. 8, fig. 16, and pl. 9, figs. 1, 2.

⁴ Mém. Soc. Géol. Fr., vol. iv, pl. 1, fig. 16.

⁵ Op. cit., pl. 22, fig. 55.

⁶ Op. cit., pl. 23, fig. 4.

⁷ Op. cit., pl. 23, fig. 5. An analogous ornamentation characterises Stache's *Cristellaria bufo* (op. cit., pl. 23, fig. 18), *Lingulina rimosa* (pl. 22, fig. 16), and *Glandulina rimosa* (pl. 22, fig. 10).

⁸ 'Ann. Sc. Nat.,' vol. vii, p. 259, No. 5; 'For. Foss. Vien.,' p. 69, pl. 3, figs. 17, 18.

CRISTELLARIA SUBARCUATULA, var. ELONGATA, *Williamson*, 1858. Rec. For., Gt. Br.,
p. 30, pl. 2, fig. 62.

MARGINULINA SUBLITUUS, *Parker and Jones*, 1860. Quart. Journ. Geol. Soc., vol. xvi,
p. 457, pl. 20, fig. 37.

— LITUUS, *Id.*, 1862. App. Carpenter's Introd., p. 310; 1865, Phil.
Trans., vol. clv, p. 343, pl. 13, figs. 14^a, 14^b.

Characters.—Shell lituate or oblong, sometimes flattened, composed of several more or less oblique segments, the earlier chambers arranged on a spiral or nautiloid plan; the later chambers usually wider, and always in a linear series. Chambers often ventricose, and the septal lines correspondingly constricted. Margin of the shell thin, but rarely carinate. Length $\frac{1}{25}$ th inch or more.

Marginulina glabra, with its feeble, elongated, smooth, partially coiled shell, is one of the intermediate links of *Nodosarina*. Indeed, a well-coiled bold specimen of this variety would have nothing to distinguish it from *Cristellaria rotulata*.

In distribution geologically, it accompanies its natural allies, commencing in the Upper Trias and reappearing in most of the fossiliferous deposits up to the later Tertiaries.

We have seen recent specimens from the west coast of Scotland (shallow water), from the Norwegian coast, the Red Sea (557 fathoms), and from the South Atlantic (260 fathoms); besides which it occurs off the coast of New Jersey, in the Mediterranean, and doubtless in many other localities.

One or two very small examples in Mr. S. Wood's collection from Sutton constitute the only evidence we have of its presence in the Crag deposits.

MARGINULINA RAPHANUS, *Linné*. Plate I, fig. 21.

NAUTILUS RAPHANUS, *Linné*, 1758. Syst. Nat., edit. x, p. 711, No. 243; edit. xii, 1767,
p. 1164, No. 283.

— GRANUM, *Id.* Ib., No. 244, edit. xii, 1767, p. 1164, No. 284.

— (ORTHOCERAS) COSTATUS, *Batsch*, 1791. Sechs Kupfertafeln, pl. 1,
figs. 1 a—1 g.

MARGINULINA RAPHANUS, *D'Orb.*, 1826. Ann. Sc. Nat., vol. vii, p. 258, No. 1, pl. 10,
figs. 7, 8; Modèle No. 6.

— SUBLITUUS, *Id.*, 1826. Ann. Sc. Nat., vol. vii, p. 259, No. 9.

— RAPHANUS, *Ehrenberg*, 1839. Transact. Berlin Akad. for 1838, p. 59,
pl. 1, figs. 2 A, B.

ORTHOCERINA MULTICOSTATA, *Bornemann*, 1854. Liasformation, p. 35, pl. 2, fig. 14.

CRISTELLARIA SUBARCUATULA, var. COSTATA, *Williamson*, 1858. Rec. For. Gr. Br.,
p. 31, pl. 2, fig. 63.

VAGINULINA SULCATA, *Costa* (n. d.). For. Foss. Terz. Messina, p. 18, pl. 2, figs. 17 A, B.

MARGINULINA RAPHANUS, *Parker and Jones*, 1862. In App. Carpenter's Introd., p. 310.

— INTERRUPTA, *Stache*, 1865. Novara-Exped., Geol. Theil, vol. i, part 2, p. 212, pl. 22, fig. 45.

— APICULATA [APICULIFERA on the plate], *Id.* Ib., p. 216, pl. 22, fig. 49.

— SPINULOSA, *Id.* Ib., fig. 51.

— TRICUSPIS, *Id.* Ib., p. 218, fig. 52.

— ASPROCOSTULATA, *Id.* Ib., p. 219, fig. 53.

— ELATISSIMA, *Id.* Ib., fig. 54.¹

Characters.—Shell elongated, subcylindrical or somewhat flattened, arcuate or straight; composed of few chambers, often ventricose, and the earlier ones often showing tendency towards a spiral mode of growth. Surface ornamented with stout ribs running from end to end of the shell. Length $\frac{1}{36}$ th inch and more.

The Marginuline form of Linné's *Nautilus raphanus* is so intimately associated with its Nodosarian form that D'Orbigny was quite correct in cataloguing them together under the name of *Marginulina raphanus*; but he made a distinction without a difference in separating the more elongate form, as *Nodosaria rapa*.

The figures in Soldani's 'Testaceographia,' to which D'Orbigny refers as illustrations of *Marginulina raphanus*, are associated on the same plate with several *Nodosariæ*, such as *N. rapa*, D'Orb. (= *N. raphanus*) and *N. scalaris*, among which the gradational conditions may be plainly seen.

The robust proportions and characteristic Nodosarian ornamentation of *Marginulina raphanus*, together with the facts that the eccentricity of its aperture is variable, and that whilst it has not the helicoid arrangement of the earlier chambers, but is rather allied to the straight varieties, it shows by its curvature the tendency to a spiral mode of growth, render it the most eligible type for the whole series of *Nodosarinæ*. In addition to its suitability on morphological grounds, it has claims for acceptance on the score of priority, as it was one of the very few Foraminifera described and named by Linné, and consequently one of the first of which we have scientific record.

Marginulina raphanus is often found among the specimens of *Nodosaria raphanus* abounding at Rimini, in the Adriatic; but otherwise it is by no means a common Foraminifer,

¹ Of these, figs. 49, 51, and 54 represent individuals in which the ribbing is weak; and, indeed, in fig. 45 the ribs fail on the last chamber. Still further, some specimens are figured as *M. angistoma* (fig. 46), *M. opaca* (fig. 47), and *M. mucronulata* (fig. 48), on the same plate, which show an absence of costation (excepting a keel in fig. 46), and more or less irregularity of growth, thus presenting the Marginuline condition of Stache's *Nodosaria erecta* (fig. 12 = *N. radicula*), just as the above-quoted costate forms and Stache's *N. striatissima* together are Nodosarian and Marginuline conditions of *Nodosaria raphanus*.

either in a recent or fossil state. We have it from various Liassic marls, and it occurs in many Tertiary deposits in company with other commoner varieties of the same type. In a living condition it is very sparingly distributed.

Mr. S. Wood found it in the Crag of Sutton, but the specimens were few and small.

Subgenus—CRISTELLARIA, *Lamarck*.

NAUTILUS, *Linné, Gmelin, Walker and Jacob, Montagu, Maton and Rackett, Pennant, Fichtel and Moll, Sowerby, Turton, Fleming, Brown, &c.*

LENTICULITES, *Lamarck, DeFrance, Nilsson, Hisinger.*

LENTICULINA, *Lamarck, DeFrance, Parkinson, &c.*

POLYSTOMELLA, *Lamarck.*

NUMMULARIA (in part), *Sowerby.*

CRISTELLARIA, *Lamarck, DeFrance, D'Orbigny, Ehrenberg, Czjzek, Reuss, Münster and Roemer, Cornuel, Philippi, Hugenow, Bronn, Morris, Parker and Jones, Williamson, Bornemann, Terquem, Carpenter, Costa, Seguenza, Brady, Karrer, &c.*

NUMMULINA (in part), *D'Orbigny.*

PHONEMUS, PHARAMUM, ANTENOR, ROBULUS, PATROCLES, SPHINCTERULUS, CLISIPHONTES, HERION, RHINOCURUS, MACRODITES, LAMPAS, SCORTIMUS, ASTACOLUS, PERIPLES, *Montfort.*

OREAS, *Montfort, Blainville.*

LINTHURIS, *Montfort, Blainville.*

SARACENARIA, *DeFrance, D'Orbigny.*

ROBULINA, *D'Orbigny, Münster and Roemer, Ehrenberg, Czjzek, Reuss, Bronn, Morris, Bornemann, Terquem, Costa, Karrer, Stache, &c.*

HEMICRISTELLARIA, HEMIROBULINA, *Stache.*

Characters.—Shell round, oval, or oblong, disco-spiral, lenticular, or compressed, bilaterally symmetrical as regards the longer axis, as is the case with the other *Nodosarinæ*; formed of a spiral set of chambers, in one or more whorls; chambers either curved or triangular, or both, and variable in size and shape, compactly set, increasing successively in size, slowly or rapidly, and more or less embracing the earlier part of the spire. Aperture excentric, either slit-like, triangular, or round, radiated, usually close to the outer or convex margin, but sometimes pouting and nearer the middle of the septal plane. Surface either smooth or ornamented with any or all of the following features—limbation of the septal lines, ribs, bars, or granules, umbonal knobs, marginal keel and spikes.

The lenticular *Cristellaria* without any keel is *C. rotulata*, Lamarck; with a keel, *C. cultrata*, Montfort; with a broad keel, commonly toothed, it becomes *C. calcar*, Linné. When much compressed and broadly keeled, it is *C. cassis*, F. and M. Some lenticular

Class—RHIZOPODA.

Order--RETICULARIA (FORAMINIFERA).

SUB-ORDER—*IMPERFORATA*.

FAMILY—MILIOLIDA.

<i>Type.</i> — <i>CORNUSPIRA FOLIACEA</i> , <i>Phil.</i>	{ 1. <i>Cornuspira foliacea</i> , Philippi	PLATE III	Figs. 50, 51.
	{ 2. — <i>invovens</i> , Reuss	III,	" 52—54.
	3. <i>Biloculina ringens</i> , Lamk.	III,	" 26—28.
	4. — <i>elongata</i> , D'O. (not figured).		
	5. — <i>depressa</i> , D'O.	III,	" 29, 30.
	6. <i>Triloculina tricarinata</i> , D'O.	III,	" 33, 34.
	7. — <i>oblonga</i> , Montagu	III,	" 31, 32.
	8. <i>Quinqueloculina triangularis</i> , D'O.	IV,	" 1.
	9. — <i>seminulum</i> , Linn.	III,	" 35, 36.
<i>Type.</i> — <i>MILIOLA SEMINULUM</i> , <i>Linn.</i>	{ 10. — <i>subrotunda</i> , Mont. (not figured).		
	11. — <i>tenuis</i> , Cz. (not figured).	IV,	" 4.
	12. — <i>Ferussacii</i> , D'O.	IV,	" 3.
	13. — <i>pulchella</i> , D'O.	III,	" 41, 42.
	14. — <i>Brongniartii</i> , D'O.	{ IV,	" 2.
	15. <i>Spiroloculina planulata</i> , Lamk.	III,	" 37, 38.
	16. — <i>canaliculata</i> , D'O.	III,	" 39, 40.
<i>Type.</i> — <i>PENEROPLIS PERTUSUS</i> , <i>Forsk.</i>	{ 17. <i>Dendritina arbuscula</i> , D'O.	III,	" 48, 49.
	18. — <i>Spirolina cylindracea</i> , Lam. (not fig.).		
	19. <i>Orbiculina adunca</i> , F. & M.	III,	" 44.
<i>Type.</i> — <i>ORBICULINA ADUNCA</i> , <i>F. & M.</i>	{ 20. — <i>compressa</i> , D'O.	III,	" 43.
	21. <i>Orbitolites orbiculus</i> , <i>Forsk.</i>	III,	" 45—47.
<i>Type.</i> — <i>ALVEOLINA MELO</i> , <i>F. & M.</i>	22. <i>Alveolina</i> , sp. (not figured).		

FAMILY—LITUOLIDA.

Type.—TROCHAMMINA SQUAMATA, *P. & J.* ... 23. Webbina hemisphaerica, *P. J. & B.* ... PLATE IV, ... Fig. 5.

SUB-ORDER—PERFORATA.

FAMILY—LAGENIDA.

Type.—LAGENA SULCATA, <i>W. & J.</i>					
24.	<i>Lagena striata</i> , D'O.	PLATE	I,	Figs. 38, 39.	
25.	— <i>sulcata</i> , <i>W. & J.</i>	"	I,	" 40—43.	
26.	— <i>laevis</i> , Montagu	"	I,	" 28.	
27.	— <i>apiculata</i> , Rss.	"	I,	" 27.	
28.	— <i>semistriata</i> , D'O.	"	I,	" 6.	
29.	— <i>gracillima</i> , Seg.	IV,	I,	" 36, 37.	
30.	— <i>marginata</i> , Montagu	"	I,	" 33, 34.	
31.	— <i>ornata</i> , Will.	"	I,	" 29, 30, 31.	
32.	— <i>squamosa</i> , Montagu	"	I,	" 7.	
33.	— <i>melo</i> , D'O.	IV,	I,	" 35.	
34.	— <i>globosa</i> , Montagu	"	I,	" 32.	
35.	<i>Glandulina laevigata</i> , D'O.	"	I,	" 1—3.	
36.	<i>Nodosaria raphanus</i> , Linn.	"	I,	" 4 & 5, 22 & 23.	
37.	— <i>raphanistrum</i> , Linn.	"	I,	" 6—8, 44 & 45.	
38.	— <i>scalaris</i> , Batsch.	"	I,	" 8.	
39.	<i>Dentalina pauperata</i> , D'O.	IV,	I,	" 13—18, 20.	
40.	— <i>obliquestriata</i> , Reuss.	"	I,	" 19.	
41.	— <i>brevis</i> , D'O.	IV,	I,	" 10.	
42.	— <i>obliqua</i> , Linn.	"	I,	" 9.	
43.	<i>Vaginulina linearis</i> , Montagu	"	I,	" 10, 11.	
44.	— <i>laevigata</i> , Roemer	"	I,	" 9.	
45.	<i>Marginulina glabra</i> , D'O.	IV,	I,	" 26.	
46.	— <i>raphanus</i> , D'O.	"	I,	" 21.	
47.	<i>Cristellaria cultrata</i> , Montfort	"	I,	" 24, 25.	
48.	<i>Polymorphina lactea</i> , <i>W. & J.</i>	"	I,	" 48.	
49.	— <i>gibba</i> , D'O.	"	I,	" 49—51.	
50.	— <i>Thouini</i> , D'O.	"	I,	" 59.	
51.	— <i>problema</i> , D'O.	"	I,	" 59.	
52.	— <i>complanata</i> , D'O.	"	I,	" 64.	
53.	— <i>gutta</i> , D'O.	"	I,	" 52, 53, 60.	
54.	— <i>tubulosa</i> , D'O.	"	I,	" 46, 47.	
55.	— <i>compressa</i> , D'O.*	"	I,	" 70—76.	
56.	— <i>rugosa</i> , D'O. (not figured).	"	I,	" 54, 65, 77—80.	
57.	<i>Dimorphina nodosaria</i> , Reuss.	"	I,	" 55—58, 61.	
58.	— <i>tuberosa</i> , D'O.	"	I,	" 66.	
59.	<i>Uvigerina irregularis</i> , Brady (not figured).	"	I,	"	
Type.—NODOSARINA RAPHANUS, <i>Linn.</i>					
Type.—POLYMORPHINA LACTEA, <i>W. & J.</i>					
Type.—UVIGERINA PYGMAEA, D'O.					

Type.—POLYMORPHINA LACTEA, *W. & J.*

Type.—UVIGERINA PYGMÆA, *D'O.*.....

* Also *Polymorphina frondiformis*, Wood, Pl. I, figs. 62, 63, 69, and Pl. IV, figs. 11—14; and *P. variata*, nov., Pl. I, figs. 67, 68.

FAMILY—GLOBIGERINIDA.

Type.—OVULITES MARGARITULA, <i>Linn.</i>	60.	Ovulites elongata, <i>Linn.</i> (not figured).			
Type.—GLOBIGERINA BULLOIDES, <i>D'O.</i>	61.	Globigerina bulloides, <i>D'O.</i>			Figs. 1, 2.
Type.—PULLENIA SPHEROIDES, <i>D'O.</i>	62.	Pullenia spheroides, <i>D'O.</i>			" 31, 32.
Type.—TEXTULARIA AGGLUTINANS, <i>D'O.</i>	63.	Textularia agglutinaus, <i>D'O.</i>			" 14—16.
	64.	— trochus, <i>D'O.</i>			" 17, 18.
	65.	— gibbosa, <i>D'O.</i>			" 10—13.
	66.	— sagittula, <i>Defr.</i>			" 7—9.
Type.—VERNEULINA COMMUNIS, <i>D'O.</i>	67.	Verneulina communis, <i>D'O.</i>			" 19.
	68.	Bulimina elegans, <i>D'O.</i>			" 1, 2.
	69.	— aculeata, <i>D'O.</i>			" 5, 6.
	70.	— marginata, <i>D'O.</i>			" 3, 4.
Type.—BOLIVINA PUNCTATA, <i>D'O.</i>	71.	Bolivina punctata, <i>D'O.</i>			" 15.
	72.	Cassidulina levigata, <i>D'O.</i>			" 16.
	73.	— oblonga, <i>Reuss.</i>			" 20—22.
	74.	— crassa, <i>D'O.</i> (not figured).			" 17.
Type.—SPIRILLINA VIVIPARA, <i>Ehrb.</i>	75.	Spirillina vivipara, <i>Ehrb.</i>			" 14, 15.
	76.	Discorbina rosacea, <i>D'O.</i>			" 3.
	77.	— Parisiensis, <i>D'O.</i>			" 11—13.
	78.	Planorbulina Mediterraneensis, <i>D'O.</i>			" 18.
Type.—PLANORBULINA UNGERIANA, <i>D'O.</i>	79.	— Ungeriana, <i>D'O.</i>			" 4—10.
	80.	— Haidingerii, <i>D'O.</i>			" 19.
Type.—TRUNCATULINA LOBATULA, <i>W. & J.</i>	81.	Truncatulina lobatula, <i>W. & J.</i>			" 22—24.
	82.	— refulgens, <i>Montf.</i> (not figured).			" 25—27.
	83.	Pulvinulina repanda, <i>F. & M.</i>			" 33—35.
	84.	— pulchella, <i>D'O.</i>			" 28—30.
Type.—PULVINULINA REPANDA, <i>F. & M.</i>	85.	— auricula, <i>F. & M.</i>			" 19—21.
	86.	— Karsteni, <i>Reuss.</i>			" 16—18.
	87.	— elegans, <i>D'O.</i> (not figured).			"
	88.	Rotalia Beccarii, <i>Linn.</i>			"
Type.—ROTALLA BECCARII, <i>Linn.</i>	89.	— orbicularis, <i>D'O.</i> (not figured).			"
	90.	Calcarina varispina, <i>D'O.</i>			"
	91.	Tinoporius laevis, <i>P. & J.</i> (not figured).			"
					"

FAMILY—NUMMULINIDA.

Type.—AMPHISTEGINA VULGARIS, <i>D'O.</i>	92.	Amphistegina vulgaris, <i>D'O.</i>			
Type.—NUMMULINA PERFORATA, <i>Montfort</i> ..	93.	Nummulina planulata, <i>Lam.</i>			" 46—48.
	94.	Operculina complanata, <i>Defr.</i>			" 51, 52.
	95.	Polystomella crispa, <i>Linn.</i>			" 49, 50.
	96.	— macella, <i>F. & M.</i> (not figured).			" 40—43.
Type.—POLYSTOMELLA CRISPA, <i>Linn.</i>	97.	— striato-punctata, <i>F. & M.</i>			" 38, 39.
	98.	Nonionina scapha, <i>F. & M.</i>			" 36, 37, 44, 45.
	99.	— faba, <i>F. & M.</i> (not figured).			"
	100.	Orbitoides Faujasii, <i>Defr.</i>			" 25.

APPENDIX II.

TABLE SHOWING THE DISTRIBUTION OF THE FORAMINIFERA IN THE CRAG DEPOSITS

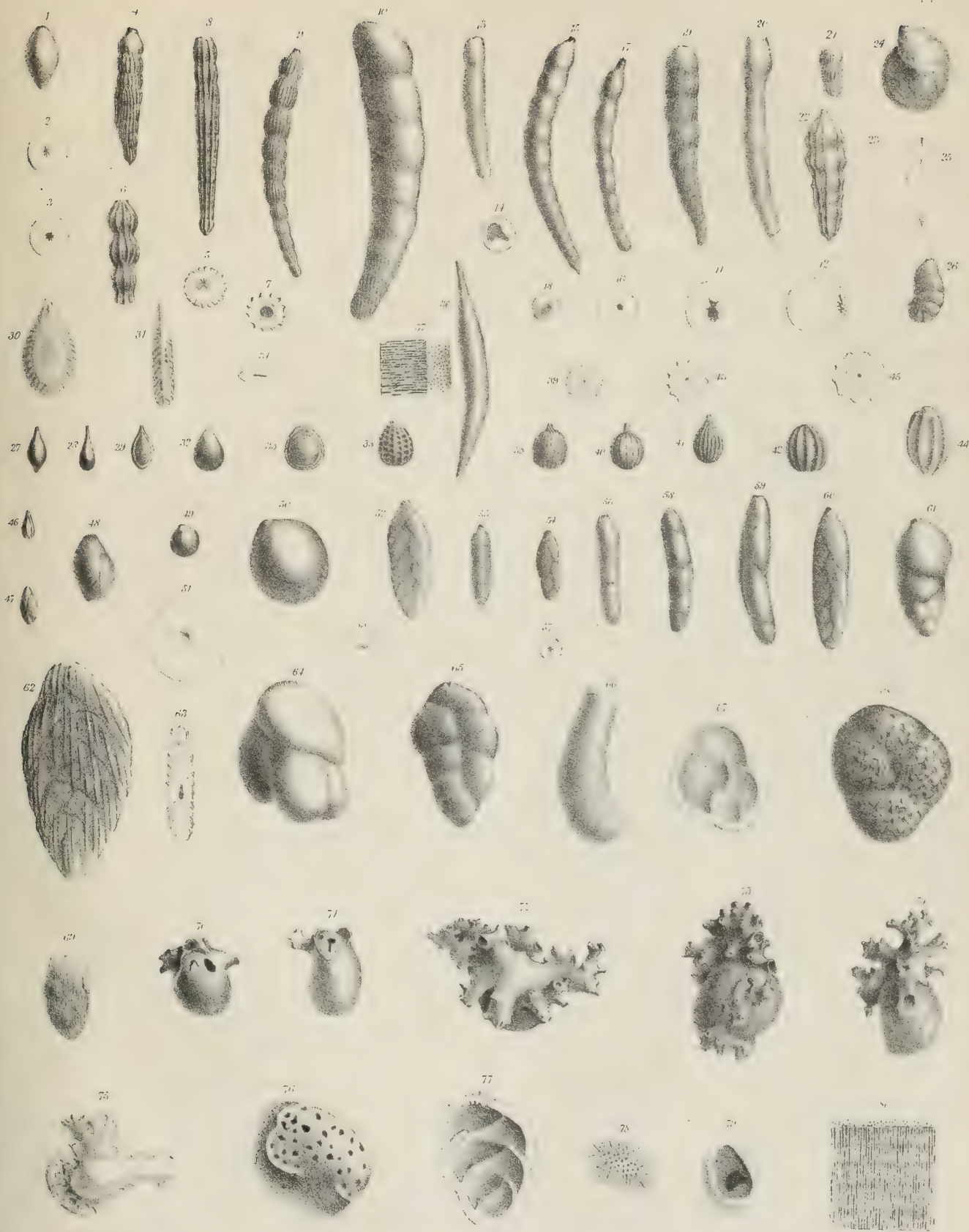
vl. Very large. l. Large. m. Middle-sized. s. Small. rs. Rather small. vs. Very small.
VC. Very common. C. Common. RC. Rather common. R. Rare. VR. Very rare.

LOWER (WHITE, POLYZOAN, OR SUFFOLK) CRAG.							UPPER CRAG.								
GENERA, SPECIES, AND VARIETIES.	From Sutton (Mr. Wood's Collection).	Sutton (not Mr. Wood's).	Crag full of Polyzoa. (Sudbourne, &c.)	Shelly Crag from Sudbourne, Gedgrave, Aldborough, &c.	Crag with Cardita senilis.	Crag with Cyprina Islandica.	RED CRAG; Essex, &c.	FLUVIO-MARINE BEDS.			Chillesford Beds.	BRIDLINGTON CRAG.	Living in the North Atlantic.	Living in the Arctic Seas.	
								Southwold.	Thorpe.	Bramerton.					
1. Cornuspira foliacea, Ph.	vl C	...	...	...	...	...	...	...	...	...	...	...	...	...	1
2. — involvens, Reuss.	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	2
3. Biloculina ringens, Lamk.	vl VC	m R	...	...	...	...	m VR	...	...	...	...	...	...	...	3
4. — elongata, D'O. ....	...	...	...	...	...	...	m VR	...	...	...	...	...	...	...	4
5. — depressa, D'O.	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	5
6. Triloculina tricarinata, D'O.	vl R	...	...	...	...	...	...	...	...	...	...	...	...	...	6
7. — oblonga, Montag.	vl C	...	...	...	s VR	...	...	...	...	...	...	...	...	...	7
8. Quinqueloculina triangularis, D'O.	l C	m R	s RC	...	...	...	...	...	...	...	...	...	...	...	8
9. — seminum, Linn.	vl C	m R	...	s VR	...	...	...	...	...	...	...	...	...	...	9
10. — subrotunda, Montag. ....	...	m R	...	...	...	...	...	...	...	...	...	...	...	...	10
11. — tenuis, Czjzek. ....	...	...	...	s VR	...	...	...	...	...	...	...	...	...	...	11
12. — Ferussacii, D'O. ....	...	...	...	l R	...	...	...	...	...	...	...	...	...	...	12
13. — pulchella, D'O.	vl VR	...	...	...	...	...	...	...	...	...	...	...	...	...	13
14. — Brongniartii, D'O.	l R	...	...	...	...	...	...	...	...	...	...	...	...	...	14
15. Spiroloculina planulata, Lamk.	vl C	...	s R	...	...	...	...	...	...	...	...	...	...	...	15
16. — canaliculata, D'O.	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	16
17. Dendritina arbuscula, D'O. ....	...	...	...	s VR	...	...	...	...	...	...	...	...	...	...	17
18. Spirolina cylindracea, Lam. ....	...	...	...	s VR	...	...	...	...	...	...	...	...	...	...	18
19. Orbiculina adunca, F. & M.	m VR	...	...	...	...	...	...	...	...	...	...	...	...	...	19
20. — compressa, D'O.	m R	...	...	...	...	...	...	...	...	...	...	...	...	...	20
21. Orbitolites orbiculus, Forak.	m R	...	...	...	...	...	...	...	...	...	...	...	...	...	21
22. Alveolina, sp. ....	...	...	m VR	...	...	...	...	...	...	...	...	...	...	...	22
23. Webbina hemispherica, nov.	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	23
24. Lagena globosa, Montag. ....	...	s R	...	m VR	m RC	l RC	...	...	...	...	...	...	...	...	24
25. — laevis, Montag.	m VR	s VR	...	...	...	...	...	...	...	...	...	...	...	...	25
26. — semistriata, D'O.	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	26
27. — striata, D'O. ....	...	...	...	m VR	...	...	...	...	...	...	...	...	...	...	27
28. — sulcata, W. & J.	vl C	m C	l C	m RR	m C	l RC	m VR	...	s R	...	...	...	...	...	28
29. — melo, D'O. ....	...	...	s VR	...	m R	...	...	...	...	...	...	...	...	...	29
30. — squamosa, Montag. ....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	30
31. — marginata, Montag. ....	...	s VR	...	m RR	m RC	l RC	m VR	...	...	...	...	...	...	...	31
32. — ornata, Will.	m R	m VR	...	...	...	...	...	...	...	...	...	...	...	...	32
33. — apiculata, Reuss. ....	...	...	s R	...	...	...	...	...	...	...	...	...	...	...	33
34. — gracillima, Seg.	vl VR	...	...	...	...	...	...	...	...	...	...	...	...	...	34
35. Glandulina laevigata, D'O.	l RC	...	...	...	...	...	...	...	...	...	...	...	...	...	35
36. Nodosaria raphanus, Linn.	s R	...	...	...	...	...	...	...	s R	...	...	...	...	...	36
37. — raphanistrum, Linn.	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	37
38. — scalaris, Batsch. ....	...	s VR	...	s VR	...	vs VR	...	...	...	...	...	...	...	...	38
39. Dentalina pauperata, D'O.	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	39
40. — obliquestriata, Reuss.	l R	...	...	...	...	...	...	...	...	...	...	...	...	...	40
41. — brevis, D'O. ....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	41
42. — obliqua, Linn.	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	42
43. Vaginulina linearis, Montag.	l VR	...	...	...	...	...	...	...	...	...	...	...	...	...	43
44. — laevigata, Roemer. ....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	44
45. Marginulina glabra, D'O.	s VR	...	...	...	...	...	...	...	...	...	...	...	...	...	45
46. — raphanus, D'O.	m R	...	...	...	...	...	...	...	...	...	...	...	...	...	46
47. Cristellaria cultrata, Montag.	m VR	...	...	...	...	...	...	...	...	...	...	...	...	...	47
48. Polymorphina lactea, W. & J.	vl VC	m R	l C	s R	m RC	m RC	...	s VC	s R	...	vs VR	...	...	...	48
49. — gibba, D'O.	vl VC	s R	l R	s R	m RC	m RC	s VR	...	...	...	...	...	...	...	49
50. — Thouini, D'O.	l C	...	...	m RC	m RC	...	...	...	...	...	...	...	...	...	50
51. — problema, D'O.	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	51
52. — rugosa, D'O. ....	...	m RR	...	...	...	...	...	...	...	...	...	...	...	...	52
53. — complanata, D'O.	vl VC	...	l C	m VR	...	...	...	...	...	...	...	...	...	...	53
54. — gutta, D'O.	vl VC	m RR	l VC	m RL	m RC	m RC	...	...	...	...	...	...	...	...	54
55. — tubulosa, D'O.	vl VC	...	...	...	...	m RC	...	...	...	...	...	...	...	...	55
56. — compressa, D'O.†	vl VC	...	l VC	...	...	...	...	s VC	...	...	...	...	...	...	56
57. Dimorphina nodosaria, Reuss.	l R	...	...	...	...	...	...	...	...	...	...	...	...	...	57
58. — tuberosa, D'O.	l R	...	...	...	...	...	...	...	...	...	...	...	...	...	58
59. Globigerina bulloides, D'O.	vs VR	s RR	s RR	m RR	s RC	...	...	vs VR	...	...	...	...	...	...	59
60. Pullenia sphaeroides, D'O.	m RC	m VR	...	m RR	m RC	m RR	s VR	...	...	...	...	...	...	...	60
61. Textularia agglutinans, D'O.	vl VC	...	...	m RC	m RC	m RR	...	...	...	...	...	...	...	...	61
62. — trochus, D'O.	l C	s RR	s RR	m RC	m RC	m RR	...	...	...	...	...	...	...	...	62
63. — gibbosa, D'O.	vl VC	...	l RR	l R	m RC	m RC	...	...	...	...	...	...	...	...	63
64. — sagittula, Deffr.	m C	s RC	s C	s C	m RC	s C	m RR	...	...	...	...	...	...	...	64
65. Verneuilina communis, D'O.	m VR	...	...	...	...	...	...	...	...	...	...	...	...	...	65
66. Bulimina elegans, D'O. ....	...	...	...	...	...	...	...	...	...	...	vs R	...	...	...	66
67. — aculeata, D'O. ....	...	...	...	...	...	...	...	vs VR	...	...	...	...	...	...	67
68. — marginata, D'O. ....	...	...	...	...	...	s R	...	...	...	...	...	...	...	...	68
69. Bolivina punctata, D'O. ....	...	...	...	...	...	s R	...	...	...	...	...	...	...	...	69
70. Cassidulina laevigata, D'O. ....	...	...	...	m VR	...	...	...	...	...	...	...	...	...	...	70
71. — oblonga, Reuss.	s R	...	...	m VR	...	...	...	...	...	...	...	...	...	...	71
72. — crassa, D'O. ....	...	...	s VR	m VR	...	...	...	...	...	...	...	...	...	...	72
73. Uvigerina irregularis, Brady. ....	...	...	...	...	...	...	m VR	...	...	...	...	...	...	...	73
74. Ovulites elongata, Lam. ....	...	...	...	m VR	...	...	...	...	...	...	...	...	...	...	74
75. Spirillina vivipara, Ehrenb. ....	...	m VR	...	...	...	...	...	...	...	...	...	...	...	...	75
76. Discorbina rosacea, D'O. ....	...	...	s VR	...	...	...	...	vs VR	...	...	...	...	...	...	76
77. — Parisiensis, D'O.	vs R	m RR	m RC	s R	s RC	s RC	s R	...	...	...	...	...	...	...	77
78. Planorbulina Mediterraneensis, D'O.	s R	m RR	...	...	...	...	...	...	...	...	...	...	...	...	78
79. — Ungeriana, D'O.	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	79
80. — Haudingerii, D'O.	m C	...	...	s R	...	...	...	...	...	...	...	...	...	...	80
81. Truncatulina lobatula, W. & J. ....	...	s VC	m VC	l C	m C	m RC	s C	s VC	m RC	...	s R	...	...	...	81
82. — refulgens, Montf. ....	...	...	...	...	...	...	m R	...	...	...	...	...	...	...	82
83. Pulvinulina repanda, F. & M.	vl RC	...	m R	...	...	...	...	...	...	...	...	...	...	...	83
84. — pulchella, D'O.	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	84
85. — auricula, F. & M.	m R	l VR	...	...	...	...	...	...	...	...	...	...	...	...	85
86. — Karsteni, Reuss. ....	...	...	...	...	...	...	...	s R	...	...	...	...	...	...	86
87. — elegans, D'O. ....	...													

† Polymorphina frondiformis, Wood (vl VC), and P. variata, nov. (l R), should also have been inserted in the column of the species and varieties collected at Sutton by Mr. S. V. Wood.

1

[illegible]



Geological Museum

PLATE II.

No. of Figure.			Magnified.	Locality from which the figured specimen was taken.		
1.	<i>Globigerina bulloides</i> , upper surface	.	×	} 12 diam. Sutton.		
2.	— — lower surface	.	×			
3.	<i>Planorbulina Mediterraneensis</i> , upper surface	.	×	12 "		
4.	<i>Truncatulina lobatula</i> , upper surface	.	×	12 "		
5.	— — — "	.	×	12 "		
6.	— — — edge view	.	×	12 "		
7.	— — — lower surface	.	×	12 "		
8.	— — — lower surface	.	×	12 "		
9.	— — — edge view	.	×	12 "		
10.	— — — upper surface	.	×	12 "		
11.	<i>Planorbulina Ungeriana</i> , lower surface	.	}	×	12 "	"
12.	" " upper surface	.				
13.	<i>Discorbina Parisiensis</i> , edge view	.	}	×	12 "	"
14.	— — — lower surface	.				
15.	— — — upper surface	.				
16.	<i>Calcarina rarispina</i> , upper surface	.	}	×	12 "	"
17.	— — — upper surface (?)	.				
18.	— — — edge view	.	}	×	12 "	"
19.	<i>Rotalia Beccarii</i> , upper surface	.				
20.	— — — lower surface	.				
21.	— — — edge view	.	}	×	12 "	"
22.	<i>Pulvinulina repanda</i> , upper surface	.				
23.	— — — lower surface	.				
24.	— — — edge view	.	}	×	12 "	"
25.	— — — <i>pulchella</i> , upper surface	.				
26.	— — — lower surface	.				
27.	— — — edge view	.	}	×	12 "	"
28.	— — — <i>Karsteni</i> , upper surface	.				
29.	— — — lower surface	.				
30.	— — — outline of the same size as the other magnified figures	.	×	12 "	}	"
31.	<i>Pullenia sphaeroides</i> , side view	.	×	12 "		
32.	— — — edge view	.	×	12 "		
33.	<i>Pulvinulina auricula</i> , upper surface	.	×	12 "	}	"
34.	— — — lower surface	.	×	12 "		
35.	— — — edge view	.	×	12 "		
36.	<i>Nonionina scapha</i> , side view	.	}	×	12 "	"
37.	— — — edge view	.				
38.	<i>Polystomella striato-punctata</i> , side view	.	}	×	12 "	"
39.	— — — edge view	.				
40.	— — — <i>crispa</i> , side view	.	}	×	12 "	"
41.	— — — edge view	.				
42.	— — — side view	.	}	×	12 "	"
43.	— — — edge view	.				
44.	<i>Nonionina Labradorica</i> , side view	.	}	×	12 "	"
45.	— — — edge view	.				
46.	<i>Amphistegina vulgaris</i> , side view; a "derived" fossil (?)	.	}	×	12 "	"
47.	— — — side view	.				
48.	— — — edge view	.	}	×	12 "	"
49.	<i>Operculina complanata</i> , side view; a "derived" fossil (?)	.				
50.	— — — edge view	.	}	×	12 "	"
51.	<i>Nummulina planulata</i> , side view; a "derived" fossil (?)	.				
52.	— — — edge view	.	}	×	12 "	"
		.				

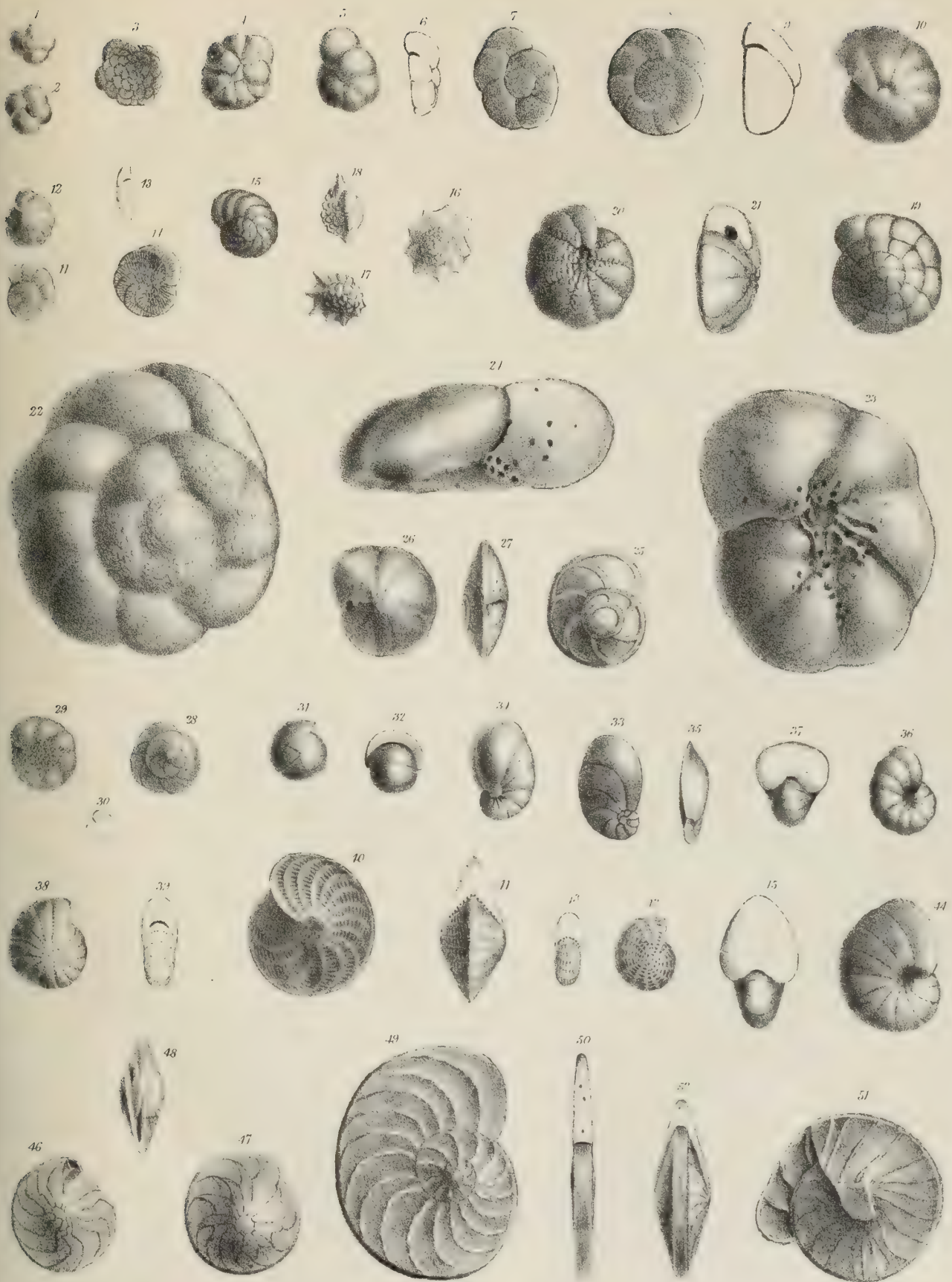


PLATE III.

No. of Figure.		Magnified.	Locality from which the figured specimen was taken.
1.	<i>Bulimina aculeata</i> , side view	× 30 diam.	} <i>Cypr. Islandica</i> Crag.
2.	— — outline—relative size	× 12 "	
3.	<i>Bolivina punctata</i> , side view	× 30 "	
4.	— — outline—relative size	× 12 "	
5.	<i>Bulimina marginata</i> , side view	× 30 "	} Southwold.
6.	— — outline—relative size	× 12 "	
7.	<i>Textularia sagittata</i> , side view	} × 12 "	Sutton.
8.	— — end view		
9.	— — side view	× 12 "	"
10.	— <i>gibbosa</i> , side view	} × 12 "	"
11.	— — end view		
12.	— — specimen partially laid open, showing subdivided chamber	× 12 "	"
13.	— — monstrous double specimen	× 12 "	"
14.	— <i>agglutinans</i> , side view	} × 12 "	"
15.	— — end view		
16.	— — transverse section, showing subdivided chamber		
17.	— <i>trochus</i> , side view	} × 12 "	"
18.	— — end view		
19.	<i>Verneuilina communis</i> , side view	× 12 "	"
20.	<i>Spirillina vivipara</i> , side view	× 36 "	}
21.	— — edge view	× 36 "	
22.	— — outline—relative size	× 12 "	
23.	Hemispherical shell of an organism possibly allied to <i>Dactylopora</i> ; a "derived" fossil	{ $a \times 50$ " $b \times 8$ "	}
24.	" " another specimen; oblique view	× 50 "	
25.	<i>Orbitoides Faujasii</i> , side view; a "derived" fossil (?)	× 12 "	Sudbourne.
26.	<i>Biloculina ringens</i> , side view	} × 12 "	Sutton.
27.	— — end view		
28.	— — thick variety	× 12 "	"
29.	— <i>depressa</i> , side view	} × 12 "	"
30.	— — end view		
31.	<i>Triloculina oblonga</i> , side view	} × 12 "	"
32.	— — end view		
33.	— <i>tricarinata</i> , side view	} × 12 "	"
34.	— — end view		
35.	<i>Quinqueloculina seminulum</i> , side view	} × 12 "	"
36.	— — end view		
37.	<i>Spiroloculina planulata</i> , side view	} × 12 "	"
38.	— — end view		
39.	— <i>canaliculata</i> , side view	} × 12 "	"
40.	— — end view		
41.	<i>Quinqueloculina Brongniartii</i> , side view	} × 12 "	"
42.	— — end view		
43.	<i>Orbiculina compressa</i> , side view	× 5 "	"
44.	— <i>adunca</i> , side view	× 12 "	"
45.	<i>Orbitolites orbiculus</i> , side view	× 12 "	"
46.	— — portion of edge of a complex specimen showing apertures	× 70 "	"
47.	— — section of a portion of ditto, showing the connection of the chambers	× 70 "	"
48.	<i>Dendritina arbuscula</i> , side view	× 12 "	"
49.	— — face of terminal chamber, showing the aperture	× 12 "	"
50.	<i>Cornuspira foliacea</i> , side view	} × 12 "	"
51.	— — edge view, showing aperture		
52.	— <i>invovens</i> , side view	} × 24 "	"
53.	— — edge view, showing aperture		
54.	— — outline, showing relative size	× 12 "	"

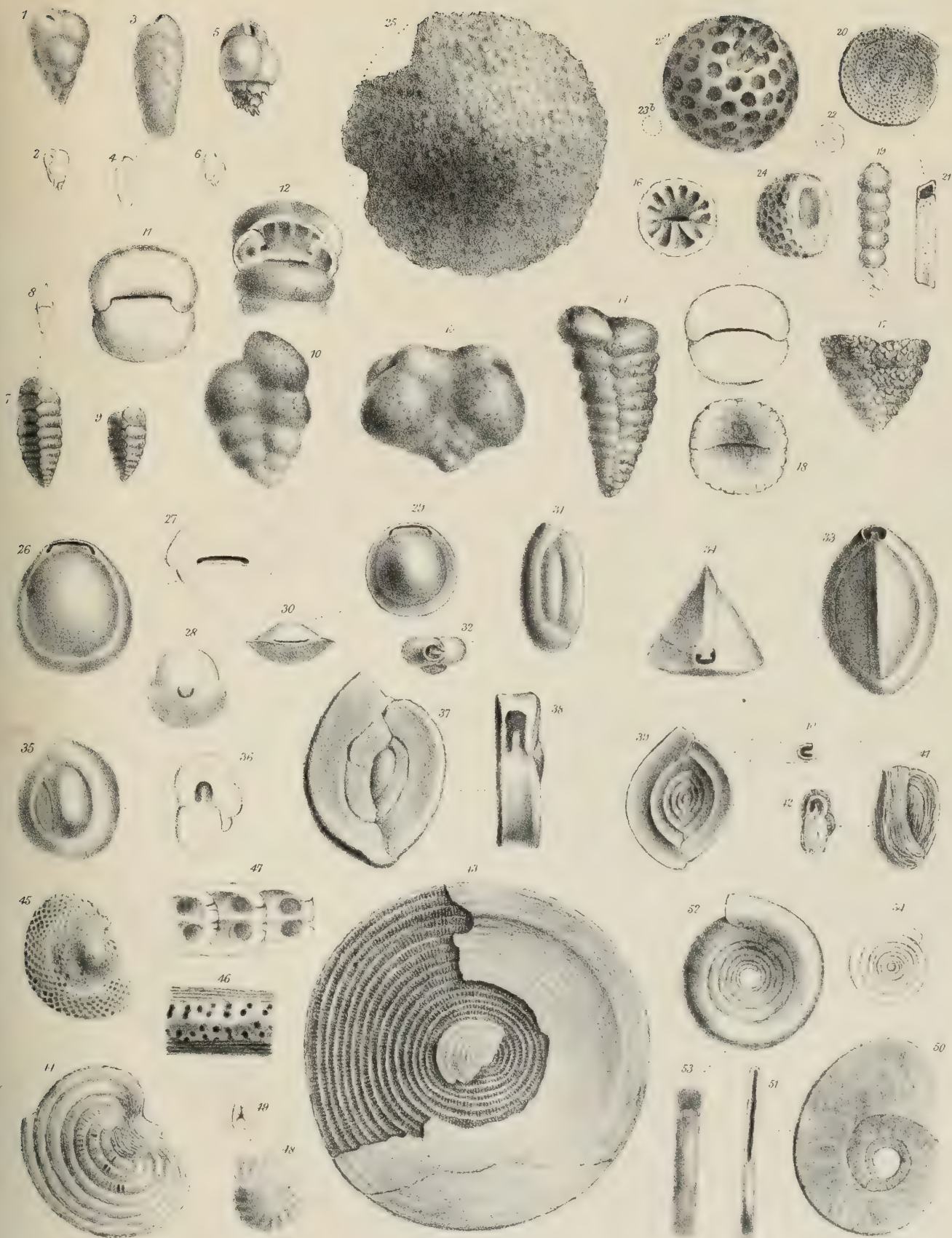
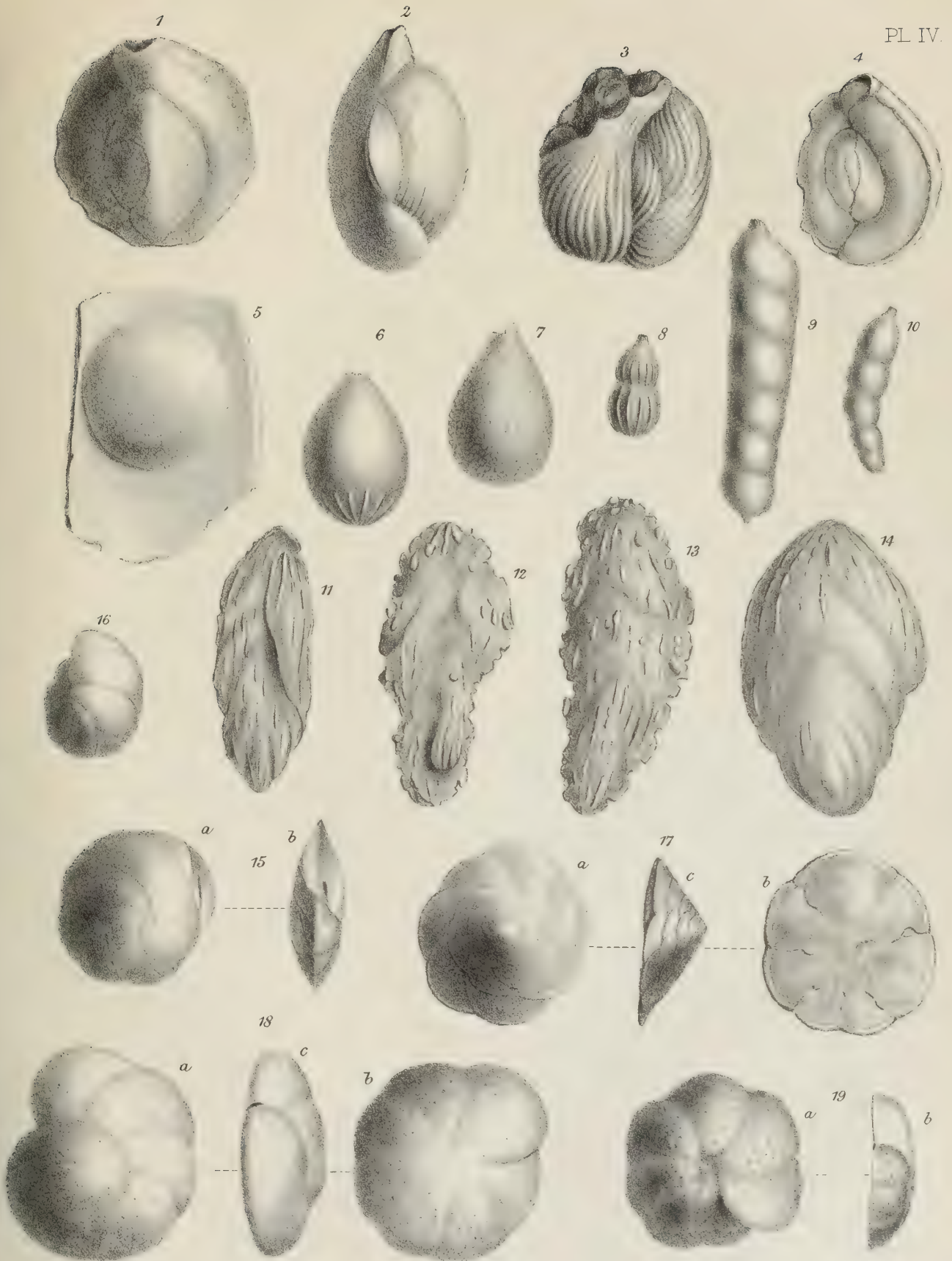


PLATE IV.

No. of Figure.		Magnified.	Locality from which the figured specimen was taken.
1.	<i>Quinqueloculina triangularis</i> , side view	× 24 diam.	Sutton.
2.	— <i>Brongniartii</i> „ .	× 24 „	„
3.	— <i>pulchella</i> „ .	× 24 „	„
4.	— <i>Ferussacii</i> „ .	× 24 „	„
5.	<i>Webbina hemisphærica</i> „ .	× 60 „	„
6.	<i>Lagena semistriata</i> „ .	× 60 „	„
7.	— <i>squamosa</i> „ .	× 60 „	Bridlington.
8.	<i>Nodosaria scalaris</i> „ .	× 36 „	Crag with Cyprina.
9.	<i>Vaginulina lævigata</i> „ .	× 12 „	Bridlington.
10.	<i>Dentalina brevis</i> „ .	× 12 „	„
11—14.	<i>Polymorphina frondiformis</i> , side views	× 12 „	Sutton.
15.	<i>Cassidulina lævigata</i> . { <i>a</i> , side view <i>b</i> , edge view }	× 60 „	Bridlington.
16.	— <i>oblonga</i> , side view .	× 60 „	Sutton.
17.	<i>Discorbina rosacea</i> . { <i>a</i> , upper surface <i>b</i> , lower surface <i>c</i> , edge view }	× 110 „	Southwold.
18.	<i>Planorbulina Haidingerii</i> { <i>a</i> , upper surface <i>b</i> , lower surface <i>c</i> , edge view }	× 24 „	Sutton.
19.	<i>Truncatulina lobatula</i> . { <i>a</i> , upper view <i>b</i> , edge view }	× 36 „	Bridlington.



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A MONOGRAPH
OF THE
BRITISH FOSSIL CORALS.

SECOND SERIES.

BY
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SECRETARY TO THE GEOLOGICAL SOCIETY.

Being a Supplement to the
'Monograph of the British Fossil Corals,' by MM. MILNE-EDWARDS and JULES HAIME.

PART I.

INTRODUCTION; CORALS FROM THE TERTIARY FORMATIONS.

Pages i—iii; 1—66; Plates I—X.

LONDON:
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1866.

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A MONOGRAPH

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PREFACE.

TWELVE years have elapsed since MM. Milne-Edwards and Jules Haime completed their great 'Monograph of the British Fossil Corals' for the Palæontographical Society.

During this period Geology and Palæontology have been very carefully studied, with the aid of all the accessories of modern scientific research. Many strata which had been considered almost unfossiliferous have been discovered to contain both known and unknown species, and those beds which yielded the specimens so admirably described and figured by the great French Zoophytologists have been successfully searched for others.

The interest in the study of the MADREPORARIA has been greatly increased since the publication of the "Introduction" in the 'Monograph of the British Fossil Corals,' for the list and the description of the genera which it contained facilitated the diagnosis of species. In 1857 the authors of that "Introduction" commenced a work which has remained the best and, in fact, the only text-book for the student of recent and fossil Corals. The 'Histoire Naturelle des Coralliaires' was completed in 1860, by Milne-Edwards, after the death of his able and amiable colleague, M. J. Haime. The anatomy, physiology, and classification of the ZOANTHARIA are admirably given in this work, and the classification is, with slight modifications, adopted by all Zoophytologists.

The distinguished authors modified many of their genera and introduced others, consequently the "Introduction" in the First Part of the 'British Fossil Corals' is incomplete and behind the day.

Many authors have added to the general knowledge of the comparative anatomy of recent Corals, and a few have given elaborate descriptions of fossil species¹ since the publi-

¹ Reuss, in his 'Beiträge zur Charakteristik der Kreideschichten in den Ostalpen,' &c. De Fromentel, 'Polypiers Fossiles.' Laube, 'Corals of St. Cassian, in Die Fauna der Schichten von St. Cassian,' 1 Abtheil. Michelotti et Duchassaing, 'Mem. Acad. Turin,' 2nd series, vol. xix, p. 279, 1861. Seguenza, 'Disquisizioni Paleon. intorno di Corall. Foss. di Messina.' There are also memoirs on the West Indian, Australian, Sindian, Maltese, and Javanese fossil Corals, by myself.

cation of the Monograph already alluded to, whilst the majority of Palæontologists have gradually learned to appreciate the value of the evidence afforded by Corals in many of the most important geological inquiries.

MM. Milne-Edwards and Jules Haime had not the advantages of the inspection of many collections made by private individuals and provincial Geological Societies, from the lower members of the Lias and from the Mountain-limestone; they had not an opportunity of studying the Coral-fauna of Brockenhurst; and time as well as some unintentional difficulties prevented their examining many of the most interesting forms from some of our Museums.

It has been felt, moreover, that although the "Introduction" in the First Part of the 'Monograph on the British Fossil Corals' was a great advance on all that had been done before, still the absence of those anatomical details which were so elaborately given in the 'Histoire Naturelle des Coralliaires' rendered the Monograph of no very great practical value.

No one could comprehend the minute details which distinguish species, by the study of the "Introduction" alone, but a very superficial examination of the 'Histoire Naturelle des Coralliaires' renders the anatomy of Corals, and the principles of their classification, easy of comprehension.

It is of very little use having detailed descriptions of species unless the anatomy of the whole class to which they belong is understood, and the publications of a Society like this should be instructive as well as recording.

A Supplement, or a Second Series, to the Monograph by MM. Milne-Edwards and Jules Haime is thought to be required. It might introduce the anatomy and physiology of recent Corals, the new genera, with descriptions of new species, and it might embody a general scheme of classification.

Following the plan adopted for the Brachiopoda in Mr. Davidson's Monograph, the relation between the hard and soft parts of the Corals will be considered, and their anatomy will be explained as correctly and as briefly as is possible. The earlier pages of this Second Series will refer to the fossil Corals of the Tertiary and Secondary rocks, and the classification of the species found in them will be given at once; that of the Palæozoic species will not be attempted until after the completion of the description of the Secondary Coral-fauna.

There will be some irregularity in the succession of the parts of the Second Series, for it is necessary to describe those large collections which can be had at once, and which might be scattered after a short period. Thus, the entirely new Coral-fauna of Brockenhurst, and many new species from Bracklesham, Barton, and Sheppey, will appear first of all; their description will be followed by that of the hitherto neglected Liassic Coral-fauna; and the Cretaceous species will be then considered, or the Oolitic, if necessary.

At the end of the description of the species from every formation, the forms already described by MM. Milne-Edwards and Jules Haime, or others, will be placed in a catalogue, and their last synonyms will be given, the name of the first describer of the

species being attached; alterations in the generic names and specific determinations by the authors of the Monograph, subsequently to its completion, will be noticed, and also whatever fresh information may be requisite about previously described species.

It is hoped that after the description of all the new species has been finished there will be an opportunity for noticing the geographical distribution of Corals, and the peculiarities of the palæontological evidence offered by them.

NOTE.—In writing this Supplement, or, as I have termed it, "Second Series," I am most anxious to acknowledge that the foundation of all my knowledge upon the anatomy, physiology, and classification of the Zoantharia was derived from the writings of MM. Milne-Edwards and Jules Haime. It will be found that the greater part of the following Introduction is taken, if not in exact words, still in ideas, from those writings; and if any palæontologist or naturalist should think that I have neglected other works, it may, perhaps, be an excuse, that it is right, in following such distinguished men as those who wrote the "First Series," to carry on their train of thought, and to choose the results of their labours in preference to those of others in compiling the "Second Series."

A MONOGRAPH
OF THE
BRITISH FOSSIL CORALS.
(SECOND SERIES.)

INTRODUCTION.

I.—GENERAL ANATOMY OF RECENT CORALS.¹

MADREPORARIA, OR SCLERODERMIC ZOANTHARIA.

WHEN a simple or solitary Coral is living in pure and well aerated sea-water its superficial soft tissues are noticed to form a *disc*, marked with a central depression and more or less covered by *tentacles*, as well as a covering to the general external surface.²

The disc is superior, and the other soft tissues are inferior to it.³

The tentacles ⁴ surround the central *mouth* at varying distances; and the mouth is capable of being elevated above the level of the disc by the protrusion of a conical process.⁵ Certain ridges or radiating lines mark the sides of the mouth (the *lips*), and extend outwards amongst the tentacles to the margin of the disc.

The margin of the disc gives origin to those soft tissues which are visible on the outside of the coral.

When any unusual stimulus is applied to the tentacles they contract, become smaller, and the conical mouth usually projects more than before.⁶ If the irritating influence persists, the mouth is retracted, the disc sinks, the tentacles disappear, and finally the hard parts of the *calice* come into view, covered simply by the flaccid and transparent soft parts. At the same time much water escapes through openings at the end of the tentacles, and the tissues covering the outside appear to lose their colour.

¹ The Introduction is illustrated by Plates I, II, III, IV, as well as by reference to some of the figures in those plates which refer more especially to species.

² Plate II, figs. 4, 9, 11, 12, 13, 16.

³ Plate II, figs. 12, 13, 16.

⁴ Plate II, figs. 4, 9, 11.

⁵ Plate II, fig. 10.

⁶ Plate II, fig. 10.

The relation of the soft to the hard parts can then be well seen, and it will be at once comprehended that there is a correspondence between the disc and the star-like upper opening of the hard parts, which is called the *calice*.¹

On examining a dried coral, or a well-preserved fossil specimen, certain plates will be seen projecting inwards from the edge of the calice like the spokes of a wheel; these are the *septa*,² and each is usually composed of two *laminæ*, but their union is so exact that it often requires microscopic sections for its determination.

On the edge of the calice, and running down the outside of the coral, are some projections, not so long as the septa, but corresponding generally with them, which are called *costæ*.³

The rim or edge of the calice, although it appears to be made up to a great extent by the bases of the *septa* and *costæ*, still presents a structure which unites their bases laterally; or, in other words, if the septa and costæ were all planed off, there would remain a more or less cup-shaped structure, called the *theca* or *wall*.⁴

The wall determines the shape of the coral; and it may be even horizontal, or more or less turbinate, cup-shaped, &c. The lowest part of the wall is called the *base* of the coral, and it may be broad or pedunculated.

The outside of the base, and more or less of the outside of the coral, are occasionally covered by a calcareous investment, which results from a soft tissue, called by Dana "foot-secretion."

The inside of the base forms the floor of a cavity, whose superior termination is the calice. This cavity is divided off by the septa, and its axis is usually filled up by a structure called the *columella*,⁵ which, in transverse sections of corals, occupies the relative position of the axle to the spokes and tire of a wheel. The upper end of the columella is free, and usually forms centrally the bottom of the calice.

In some corals⁶ there are thin processes, which are more or less oblique or even horizontal in their direction; they are situated between the *septa*, and they separate the cavity into compartments, the upper or calicular being the newest. In other forms these dissepiments (*dissepimenta*) are nearly vertical; and in one great series they simply connect the septa laterally, without dividing or restricting the cavity. These latter processes are called *synapticulæ*.⁷ Horizontal dissepiments are termed *tabulæ*.

There are corresponding processes between the *costæ* in many corals, and they are often so fully developed as to project beyond and over them. The processes which are inside the wall and between the septa compose the *endotheca*,⁸ whilst those without the wall and in relation to the *costæ* are termed *exotheca*.⁹

The "foot-secretion" is an *epitheca*.¹⁰

¹ Plate II, fig. 11.

² Plate I, figs. 1, 3, 14, 18.

³ Plate I, figs. 2, 7, 11.

⁴ Plate I, figs. 3, 4, 14, 15, 17, 18.

⁵ Plate I, figs. 5, 6, 8, 10, 12, 14, 18.

⁶ Plate I, figs. 15, 13, 18.

⁷ Plate III, figs. 1, 2.

⁸ Plate I, figs. 13, 15, 18.

⁹ Plate I, figs. 11, 18.

¹⁰ Plate I, fig. 16.

On looking into a calice and down the internal cavity the vacant spots between the septa become apparent; these are the *interseptal loculi*; they are restricted in depth when dissepiments exist, and extend from the bottom to the calice when there is no endotheca.¹

The septa vary in size, and may or may not reach from the wall to the columella, and all the space left between them, restricted or not by dissepiments or *tabulæ*² (horizontal dissepiments), forms in living corals part of the *visceral cavity*. When there is no columella there is a central space, into which the interseptal loculi open; the visceral cavity is then all the larger, but the depth of its inferior boundary always depends upon the existence of the endotheca. The septa are frequently raised in an arched form³ above the level of the top of the *wall* (theca); and a line carried across their tops over the calice would bound a cavity whose base is the top of the columella and the internal ends of the septa. This cavity is the *calicular fossa*; the interseptal loculi open into it, and it is very variable in size and depth. When the columella is very prominent the calicular fossa is all the more restricted in depth; but when the wall is high, the columella absent, and the septa not exsert, the fossa is deeper.

It will now be evident that the hard parts of a coral form the boundaries to a system of cavities (the interseptal loculi), and to the calicular fossa, into which they open.

The disc, in living corals, elevated very slightly above the tips of the septa, closes the calicular fossa above, and opens into it over the columella, so that when the mouth is widely open the markings on the free surface of this structure can be seen faintly covered by the tissue which lines all the hard parts of the coral above the newest dissepiment or the base, as the case may be.

The septa, dissepiments, and the columella, being covered with a soft tissue, which is continuous with the margin of the disc, it is evident that there is a cavity in the soft parts of the coral which corresponds with that already mentioned as being within the calcareous portion.

Thus, the *interseptal loculi*, *calicular fossa*, and the space between the tops of the septa and the disc, all lined by continuous soft tissue, form the whole *visceral cavity*.

The *mouth*, seen on the upper surface of the disc, opens into a short stomach, which in its turn opens into the visceral cavity by means of a *pyloric orifice* situated above the level of the top of the columella (or junction of the inner ends of the septa when there is no columella).

The *stomach* is an inversion of the membranes of the disc, is tubular, ridged longi-

¹ Plate I, figs. 5, 14.

² Plate III, figs. 9, 11, 16.

³ Plate I, figs. 4, 14, 15.

tudinally, and very short. It is bounded above by the lips with their ridges,¹ below by the pyloric constriction, and its outside is free in the visceral cavity.

The ridges correspond with *mesenteric folds*, which are attached to the under surface of the disc and to the outer or visceral surface of the stomach. Where the *mesenteric folds* are attached to the lower margin of the stomach (the pyloric constriction), some *tubular prolongations*² arise which float in the visceral cavity. There is an intimate relation between the mesenteric folds, the septa, the interseptal loculi, and the tentacles. These last open inferiorly into the visceral cavity between the mesenteric folds; and, being hollow and also perforated at their free extremity, they connect the visceral cavity with the outside. The septa are developed between the mesenteric folds, and correspond with the *subtentacular spaces*.

There are, in some species, processes which are internal and accessory to certain septa; they arise from the base internally, and pass upwards in the form of thin plates, and are attached to the columella. These are the *pali*.³

The costæ and the exotheca are covered by, and, like all the other hard parts, are developed by, soft tissues.

The coloration of the soft tissues is very varied and beautiful; they are, of course, not preserved in the fossil state, but they occasionally leave behind them the chemical proofs of their former existence.

The soft tissues are—

1. The disc and its accessories.
2. Membranes of the visceral cavity.
3. Stomach.
4. External membranes.

The disc supports the tentacles and forms the lips. The external membrane covering the costæ arises from its external margin. It is marked by radiating ridges.

The membranes of the visceral cavity line the interseptal loculi, and cover the septa, wall, pali, and columella; they form also the mesenteric folds and the tubular processes.

The stomach, formed by membranes continuous above with those of the disc and below with those of the visceral cavity, is bounded above by the mouth with its lips, which are capable of being extended above the level of the disc.

The foot-secretion or *epitheca* has its especial membrane.

The membranes or tissues of these cavities of the disc and tentacles consist of three layers.

The *Sclerenchyma*, skeleton, or calcareous polypary—the hard parts, as they may be more simply called—consist of the *wall* or *theca*, *septa*, *costæ*, *columella*, *pali*, *endotheca*, *exotheca*, and *epitheca*.

¹ Plate II, figs. 11, 13.

² Plate II, fig. 2.

³ Plate I, figs. 8, 9, 10, 14, 18.

The base, sides, calice, calicular edge or margin, are self-explanative terms. The terms calicular fossa, and interseptal loculi, have been noticed.

These are the usual structures observed, and they are modified in every way to produce the various shapes of corals.

The word *corallum* is used to individual corals when solitary in their growth; but when aggregated to form a compound mass each individual of the mass is called a *corallite*, the aggregation retaining the name of *corallum*.

The *corallites* of a compound *corallum* may be united together by the fusion of their walls, no costæ existing, or they may be united by a great development of the costæ and the exothecal dissepiments. Sometimes the exotheca is so developed as to form a very distinct tissue between the corallites; it is then more or less cellular, and is termed *cænenchyma* and *peritheca*.

Some simple and many compound corals extend by a process of lateral calicular growth, so that there is not a circular or ovoid calice, but a long, and often gyrate assemblage of septa; such a calice is called "*serial*." The shape of compound corals is determined, to a great extent, by their method of *gemination*,¹ and by the existence of *fissiparous*² and *serial*³ *calices*.

II.—ANATOMY OF THE SCLERENCHYMATOUS STRUCTURES.

Calice, Wall, Septa, Pali, Columella, Costæ, Endotheca, Exotheca, Epitheca, Peritheca, Cænenchyma.

Calice.—The upper and open extremity of a corallum is called its *calice*.⁴ Its outline is formed by the upper or marginal part of the *wall*, and is very various in its form. The superior boundary is determined by the greater or less exsertness of the *septa*, and its depth by the greater or less prominence of the structures forming the floor of the *fossa*.

The periphery of the calice is called its margin, and its floor is formed by the septa, the interloculi, the top of the columella, and, when that structure does not exist, by the axial space.

Every variety of form may be noticed in the outlines of calices; they may be circular, circular and slightly compressed, oval, elliptical, elliptical and slightly angular at the end of the long axis, ovoid and compressed from side to side, ovoid at one end, linear or leaf-

¹ Plate III, fig. 15; Plate IV, figs. 10, 11, 17, 18.

² Plate IV, figs. 12, 13.

³ Plate IV, figs. 14, 15.

⁴ Plate I, figs. 1, 11, 6; Plate II, figs. 11, 13, 14; Plate III, figs. 15, 17, 18, 19, 20; Plate IV, figs. 8, 11, 12.

shaped, wavy in their outline, nipped in centrally or in the figure of eight, more or less square, pentagonal, hexagonal, polygonal, polygonal and elongated, linear or serial, serpentine, &c.

The margin is not always on the same plane throughout. It may be ridged, so as to form an ornamental series of projecting angles; the plane of the minor axis may be much higher than that of the major, and *vice versâ*. In corals which are simple and horizontal the wall is covered completely by the calice, and the septa are necessarily very exsert.

The calice may be prominent, and even placed at the end of a cone, or may be depressed below the surface, as in many compound corals. Calices may be distant or connected together by their walls, or they may form series by a succession of calices running one into the other in a linear or radiating direction.

The opening of the calice may be very wide and everted or contracted and inverted; the calice may be deep, shallow, wide, narrow, and widely open; its margin may be broad, flat, or narrow, and sharp; moreover, it may be below or above the bend of the top of the septa. Deformed calices are produced by the pressure incident to the growth of crowded corallites in a compound corallum, and a great number of calices are more or less altered in outline by the phenomena of fissiparous and calicinal reproduction.

The calices vary in size on different parts of the same corallum.

In some genera one half of the calicular margin may be lip-shaped or more elevated than the other, and in a few the distinction between the calicular fossa and the general surface is by no means easy.

Wall.—The wall gives support to the costæ externally and to the septa internally, and it can be seen in the most complicated corals between the costæ at the bottom of the intercostal spaces and between the septa, where it bounds externally the septal interloculi. It determines the shape of the corallum and the amount of its solidity; moreover, it has intimate relations with the columella and endotheca, as well as with the exotheca.

The hardness and thickness of some walls¹ is as remarkable as the porosity, reticulate character, and fragility of others, and the so-called perforate² condition of the last is always noticed in an important section of the *Madreporaria*. Every possible variety of thickness and solidity may be noticed, as well as of fragility, thinness, and porosity; moreover, these opposite conditions are brought together by the existence of perforations in comparatively solid walls.

Usually the wall is a very prominent feature in the corallum;³ but it may become so united to exothecal structures or to the cœnenchyma as to be indistinguishable from them; and in some large simple corals, where the epitheca is strongly developed, the wall is either rudimentary or has become absorbed.⁴ In these species the coral is kept together by the enormous development of the dissepiments or tabulæ.

¹ Plate I, figs. 3, 14.

² Plate III, figs. 3, 4; Plate IV, fig. 18.

³ Plate I, figs. 3, 14.

⁴ Plate IV, fig. 6.

Some simple forms have walls which are moderately stout superiorly and excessively thick and hard inferiorly, so as to encroach on the visceral cavity; this filling up of the lower part of the corallites is observed in some compound corals. It is very evident that the thickness and the hardness of the wall are determined by the nutrition of the coral; but no defect in this will produce the perforate condition.

Two series of wall-shapes are noticed,—one more or less horizontal and the other ranging from a shallow cup to a long cylinder in shape; the square, polygonal, and compressed outlines of some walls are either the result of pressure or are characteristic of the species.

The horizontal wall produces shallow, disc-shaped corals; the septa arise from its upper and the costæ from its lower surface. In some species the under surface is concave, so that the cup-shape is seen reversed.

The second and commonest form may be slightly horizontal at first, and with growth the edges turn up and enclose the calicular cavity; then any height, width, and contortion may result; the turbinate, subturbinate, conical, conico-cylindrical, tubular, and other forms, may thus arise.

The wall forms the most important part in some corals, but only a secondary in others; it may be uncovered externally by costæ or by epitheca, or it may be in such close contact with neighbouring walls, in compound corals, as to become fused.¹ The upper termination or margin of the wall is very visible when the septa are not exert; and in compound corals, when the walls have become united, this margin may be sharp or broad, and variously marked. Usually the walls of neighbouring corallites (not fused together) are separated by a dense tissue, which is ornamented superiorly, and often traversed by costæ.

The wall occasionally gives out processes, and is often marked by growth-rings, constrictions, and ridges. It is rarely symmetrical; for most simple corals are curved, twisted, or more or less compressed; and this is equally true as regards the compound. The base of the wall is often attached to foreign substances, and may be broad, even concave from rupture, or very delicate and pedunculate. The epitheca, where it exists, is generally more strongly developed over the base; the inner base is the floor of the visceral cavity.

Septa.—The septa have been already noticed in a general manner; and it has been mentioned that they are developed between the mesenteric folds, and that they are localized in the intermesenteric or subtentacular spaces.

The number of tentacles has a direct ratio to that of the septa and pali.

The septa, in their simplest condition, are spiniform agglomerations of nodules, projecting slightly into the calice from the wall,² and there is every imaginable variety

¹ Plate III, figs. 3—16; Plate IV, fig. 11.

² Plate III, figs. 5, 6.


of structure between these and the highly developed septa of some Tertiary corals, where the laminae composing the septa are distinct, very long, broad, and imperforate, very much arched and exsert, beautifully dentate on their free upper margin, and magnificently ornamented with granules in regular series.¹

The number of septa in a calice varies in many species, and there is great diversity in their arrangement. The number and arrangement of the septa differ according to the age and development of the individual, to a certain extent. Many species have six septa, never more and never less; others have a second series, and a new septum is introduced between each of the old. Thus twelve septa and no more are found in a species of *Alveopora*. (Plate III, fig. 5.)

The six septa which appear first of all, are termed the *primary*, and they constitute a *cycle* or *order*; the next six, which are developed between the primary, are termed the *secondary*, and constitute a second cycle. The *Alveopora* has, then, two cycles of septa, or six primary and six secondary. In very many species other septa are developed, which are always found regularly distributed, one occupying each interseptal locus. That is to say, in every interseptal locus between the original primary and the after-coming secondary septum a third arises from the wall. There are, therefore, twelve of these tertiary septa, and the twelve form the *third cycle* or *order*. The three cycles, first, second, and third, combined, form twenty-four septa.² That is to say, between two primary septa there is one secondary and two tertiary septa. These septa between the two primary constitute a *system*; and when the primary septa are six in number there are six systems. If there be twelve septa, there are six systems of two cycles; and if there be twenty-four, there are three cycles in six systems.

There are interocular spaces between the first septa and the tertiary, and between the tertiary and the secondary; any more septa must be developed one by one in these spaces. The additional septa are, in fact, developed in the space which intervenes between the first and the third septa, and simultaneously others come in between the second and the third septa, so that in each system four more septa arise. Those between the primary and tertiary constitute the *fourth order* of the *fourth cycle*, and those between the secondary and the tertiary the *fifth order* of the *fourth cycle*. The septa arise simultaneously in all the systems in this manner.³

The number of the septa in the last instance is forty-eight, or five orders of four cycles in six systems. Each system contains the following orders:

1st.	4th.	3rd.	5th.	2nd.	5th.	3rd.	4th—1st.
							
8							

Any other septa are introduced between the primary and the fourth septa, then

¹ Plate I, fig. 15.

² Plate IX, figs. 5, 6.

³ Plate V, figs. 3, 4, 9.

between the secondary and the fifth; then others between the third and fourth and third and fifth. This regular cyclical arrangement multiplies the septa rapidly and regularly, and determines the symmetry of the calice and of the tentacular disc. When the fifth cycle is complete, there are ninety-six septa, or sixteen in each system.¹

When six cycles are developed, no less than 192 septa result; and seven cycles, when perfect, produce 384.

It is rare for these higher cycles to be complete and the septa are aborted in many of the interlocular spaces.

The primary septa are usually larger, more exsert, and extend further inwards than the others; but, as the cycles become complicated, the secondary and even the tertiary septa often resemble the primary. Nevertheless, in the majority of instances, it is easy to determine the orders of the septa. The development of six systems of septa is seen in the majority of corals, but there are some very curious and important exceptions to its universality. Some species have four, five, eight or ten systems, and a corresponding number of large or primary septa. Moreover, monstrosities often occur, and produce an extra system, with a normal cyclical arrangement.

The pentameral, octomeral, and decemeral² arrangements are accounted for either by the abortion or duplication of a system or by their being natural and normal types.

The palæozoic corals belong generally to species in which there are four primary septa, or in which vacant spaces produced by aborted large septa are counted with the other large septa. But even this generalization is not free from great exceptions, and there are many genera where no trace of the quaternary septal arrangement is to be made out.

It must be acknowledged that septa do not always exist, and in the genus *Axopora* there is a proof of this.³

The septa thus elaborated as regards their succession and number present many peculiarities in their direction, size, length, breadth, height, exsertness, ornamentation, and in the structure of their lamellæ and margins. They usually pass directly inwards from the wall towards the columella or the centre of the calicular fossa and middle of the visceral cavity; occasionally they vary in this course; and it is by no means uncommon for the smaller septa to turn towards and even to join their larger neighbours. In calices where there is fissiparous growth, or the development termed serial, the septa pass inwards almost at right angles to the wall.

¹ Plate V, fig. 16.

² De Fromental, 'Introduct. Polyp. Foss.,' may be consulted concerning these unusual types; and see my "Memoirs on Maltese and Australian Tertiary Corals," 'Ann. Nat. Hist.,' Sept., 1865.

³ Plate VII, figs. 11, 12, 13, 14.

There is every possible variety in the size of the septa; but, as has already been mentioned, the primary are the largest, and the members of the higher orders the smallest.

The same observation holds good, as a general rule, with regard to the height. The exsertness of septa varies greatly; some are arched and extend far higher than the top of the wall, and others do not extend upwards above the wall at all. The longer septa in some species meet and are twisted centrally, whilst those of the higher orders only just project within the calice.

The breadth of the septa depends very much on the habit and size of the corallum; the bi-laminate arrangement is very distinct in some species, whilst in others it cannot be seen, and the septa are thin, delicate, and very fragile. The genus *Dasmia* has a tri-plated arrangement of the septa.

The thickness of the septa varies in corals of the same genus, and it becomes of some importance in a diagnostic sense.

Usually all the septa are thickest at their origin from the wall, they then thin off towards their inner edge, but very often there is an increase of their bulk near the columella and midway.

The ornamentation consists of ridges, papillæ, spines, and granules, which are variously arranged in radiating, parallel, or irregular series.

The structure of the laminæ differs in many species. The laminæ may be dense and imperforate, or more or less perforate generally or only in certain parts. In some corals the septa are mere spiny processes, in others they are spongy in appearance, and in the other extreme they are very dense and solid.

The upper or superior margin of the septa is free, and the inner margin or end is towards the columella or long axis of the corallum. The upper margin may be smooth or incised, lobed or entire, granular or largely dentate, serrate and spined; it may be arched, or may be directed downwards and inwards, and it may be enlarged at any part.

The inner end or margin may be free, may join a columella by processes of dense or of lax hard tissue,—may send off processes to form a columella, with others from other septa,—may be attached to pali,—and it is often very ragged, twisted, clubbed, and perforate.

The inner ends of small septa may become attached to the sides of the larger.

Finally, the sides of the septa are marked more or less by the *dissepiments*¹ and *tabulæ*,² and they give origin to these structures as well as to the *synapticulæ*.³

NOTE.—The description of the septa of the *Rugosa* is omitted until the introduction to the palæozoic corals is commenced. For an exhaustive essay on the septa, see Milne-Edwards and J. Haime, 'Hist. Nat. des Corall.,' vol. i, p. 40. M. E. de Fromentel's criticisms on it, and his own able descriptions, may be found in his 'Introduction à l'étude des Polypiers Fossiles,' p. 18.

¹ Plate I, figs. 12, 13, 15; Plate IV, fig. 4. ² Plate III, fig. 16; Plate IV, fig. 2. ³ Plate III, fig. 2.

Pali.—The pali¹ are the small processes which exist between certain septa and the columella. They generally arise from the base of the visceral cavity, or close to it, and pass upwards, united by one edge to the columella, and by the other to the inner end or margin of the septa. When there is no columella they are adherent to the septa, present a free edge to the cavity in the axis of the corallum, and arise with the septa.

The upper or free margin of the pali is usually lobed, and is thicker than the end of the septum to which it corresponds; it may project higher than the end of the septum, and may form a very marked feature in the calicular fossa.

The sides are more or less broad, and are usually ornamented differently to the septa.

The inner and outer edges are united to the septa and columella, either by processes or by a perfect fusion.

The number and size of the pali vary in different species. The pali may exist before (or rather internally to) one or several orders of septa, and they are then said to form one or more crowns.

The development of the pali has often, but not invariably, a very singular relation to that of certain septa. Thus, when there is but one row or crown of pali² they are placed at the inner edge of the penultimate septa; and when there are two rows, or crowns, they may be seen at the inner edge of the penultimate and antepenultimate cycles of septa. In some corals with numerous septa pali are found in contact with all the septa, except those which have been developed the last—the last cycle. In others the pali are found in relation to all the cycles. One genus has the pali attached to all the septa except those of the cycle which precedes the last, and a genus well marked in the West Indian fossil coral-fauna has no pali before the principal septa, but they exist before the penultimate and antepenultimate cycles.

There is a curious relation between the perfection of the septal development and the presence of pali. Milne-Edwards and J. Haime have proved that, if in one half of a system the cycles of septa are not complete, there is a corresponding absence of pali; thus, a coral with four cycles may have pali before the secondary and tertiary septa; but if one or both of the orders of the fourth cycle are wanting in one half of a system there would be no pali before the tertiary septum of that half-system.

When there is a columella the appearance of the pali is generally very distinct, at the same time they may be confounded with its papillæ; but when the calice has been worn away, the attachment of the pali to the columella is often so distinct that they may be mistaken for the ends of large septa.

The large spines on the inner end of some septa, or some enlargement of the laminae at that spot, may be mistaken for pali, and the terms paliform tooth and swelling are very

¹ Plate I, figs. 8, 9, 10, 14, 18.

² For an exception, see pali in *Porites panicea*, Lons.

commonly met with. In the genus *Acervularia* the distinguishing of so-called paliform lobes or enlargements and teeth is sufficiently difficult.

The number of genera without pali is very considerable.

Columella.—This structure is in the axis of the coral, and may be noticed in the centre of the calice or of transverse sections of corallites, whilst in longitudinal sections it is to be seen passing from the base upwards, having the pali or septa on either side.¹

The columella is not invariably present, but in some species it forms the most important part of the calicular apparatus.² The most highly developed columellæ spring from the centre of the base of the young corallum, increase in height with the growth of the septa, and always appear as prominent organs in the calice. These columellæ grow independently of the septa, and are not formed by their internal and free terminations. For this reason they are called "*essential*" or "*propria*;" they generally assume the styliform, the fasciculate, or the lamellar character, and may or may not have pali attached to them.³

The second kind of columella is termed "*septal*," and is produced by the inner ends of the septa dividing into longitudinal "poutrelles." They have a fascicular arrangement. These "septal" columellæ are rare, and may, for all practical purposes, be considered with the next kind.

The third kind of columella is formed by the septa dividing into numerous processes before they approach closely; the processes unite centrally, and throw out lateral growths, so that a more or less dense, spongy, or cellular structure results. This columella is termed *parietal*, and may be very highly developed or may be rudimentary. In the latter instance the columella may only be recognised by a slight bifurcation of the inner ends of the septa, with a sparsely developed cross tissue.

False columellæ are formed by the soldering together of the inner ends of two or more septa, by the twisting of the inner ends of several septa, and by the presence of endotheca close to the septal inner margin.

Rudimentary columellæ are often observed, which cannot be classified with any of the above; they may be formed by a lateral junction of the inner ends of the larger septa, by processes connecting them, and by the inner ends becoming clubbed in outline, and more or less irregular in their direction.

There are many modifications of these varieties of columellæ, but their division into essential, septal, parietal, and false, is of great practical value, and they can always be distinguished with care. The calicular terminations of the columellæ vary in size, projection, outline, and arrangement.

¹ Plate I, figs. 5, 6, 10, 18.

² Plate VII, fig. 12.

³ Plate I, figs. 5, 6, 8, 10, 12; Plate IX, figs. 3, 6, 10.

Amongst essential columellæ the styliform may end in a cylindrical and pointed process, or in a more or less compressed and blunt, which may project even higher than the septa, or in a bulbous termination marked by ridges corresponding with large septa; or the organ may be angular in transverse outline, and project but slightly above the bottom of the calicular fossa. The styliform columellæ may be studied in the genera *Turbinolia*, *Synhelix*, *Stylophora*, *Axosmilia*, *Stylosmilia*, *Stylina*, *Holocænia*, *Stylocænia*, *Astrocænia*, *Stephanocænia*, *Holocystes*, *Cyathoxonia*, *Syringophyllum*, and *Phillipsastræa*. They are nearly solid, spring from the base, and may or may not be attached by processes to the septa. Very visible in well-preserved specimens, these columellæ are readily destroyed by rolling, and cannot then be distinguished except by sections. In many species, especially in the *Astrocæniæ*, the columella appears to be very large in certain fossil conditions; but this appearance arises from a mechanical adhesion of calcareous particles to the outside of the columella and between the inner ends of the septa. There are examples of styliform columellæ (Plate IX, figs. 3, 6, 10).

The lamellar form of essential columella (Plate I, fig. 6; Plate IV, fig. 14) may occur in circular, elliptical, or in elongated calices. It is seen as a sharp edge, generally at the bottom of the calicular fossa, and may be in contact both with septa and pali. Its sides are occasionally ornamented with granules. In the genus *Madrepora*, and in some species of *Solenastræa* this lamellar columella does not really exist, but is simulated either by the junction of opposite septa or by the irregular development of neighbouring septal ends. The true lamellar columella is not formed by septa, but springs from the base of the corallum.

The fascicular columella is a very complicated organ. In its simplest form it is a bundle of rods coalesced laterally, adherent below, and rounded at the free calicular surface.

This structure is well seen in the genus *Axopora* (Plate VII, fig. 14), and in an Australian fossil, the *Conosmilia anomala*¹ (nobis). Here are two riband-shaped processes arising from the base, and projecting in the calicular fossa; each is simply twisted five or six times, so that the riband's edge takes on a spiral form; this is the simplest form of the common fascicular columella, and in Plate I, fig. 13, several processes, really riband-shaped, but much twisted, are seen in lateral contact, the whole forming the columella. The number of the processes varies in different species, and it is tolerably constant in certain forms; the processes, were they untwisted, would form a number of flattened and lamellar columellæ in lateral apposition. The septa and pali do not contribute to their formation. The calicular surface of the fascicular columellæ may be papillary, or even twisted; and it most frequently resembles the arrangement of the central portions of the flowers of certain Compositæ; hence the term "chicoracé," which is most significant and explanatory of the appearance of the calicular surface of the columella in the genus *Caryophyllia*.

¹ 'Ann. Mag. Nat. Hist.,' ser. 3, vol. xvi, pl. viii, fig. 4e.

The septal columellæ may be mistaken for the fascicular and essential ; but a longitudinal section will show that the inner edges of the septa forms the organ, and that it does not arise from the base.

The parietal columellæ are very common, and their structure is illustrated (Plate IV, fig. 13 ; Plate VII, fig. 9).

The calicular surface of the columella may be prominent or depressed, papillary or spongy ; and the organ may be very dense or consist of very lax tissue.

The columellæ of the following genera may be studied with regard to this variety :—*Parasmilia*, *Eusmilia*, *Dendrosmilia*, *Lithophyllia*, *Circophyllia*, *Rhabdophyllia*, *Mæandrina*, *Manicina*, *Diploria*, *Heliastrea*, *Solenastrea*, &c.

As a general rule, when pali exist, they are in close contact with the columella, and as they spring from the base they often look like lateral processes of essential columellæ. It will be observed, in the descriptions of living corals, that the columella fills up much of the visceral cavity, and is developed by the inner layer of the soft tissues. Playing a very important part in the economy, and being in relation both with the septa and pali, the columellæ are structures whose variations in form are of generic import.

Costæ.—The costæ may be considered in a general sense to be the continuations of the septa beyond the wall.¹

In some *Turbinoliæ* the continuity between the costæ and the exsert septa is very evident, and both of the structures are much higher than the upper margin of the wall.² But it is very probable that this exsert condition of the septa and costæ is to be referred to the corallum having attained its full development as regards height ; the further upward growth of the wall was arrested, and only the combined costo-septal apparatus grew on. For when the costæ of the same specimens are broken off low down, it is tolerably evident that the wall intervened between their bases and those of the corresponding septa.

It would appear that the costæ and septa are not developed by the same parts of the soft tissues except when they are exsert and above the wall ; and the want of correspondence between the septa and costæ about to be mentioned is in consequence of this.

It is probably quite correct to give the costæ an origin independent of the septa, and to assert that they are frequently separated by the thickness of the wall from the septal laminæ.

The costæ are developed by the inner layer of the tissue which covers the wall externally, and the outer surface of the wall and the exothecal structures are also formed by it. The costæ follow, as a rule, the cyclical development of the septa, and are called primary, secondary, &c.

¹ Plate I, figs. 2, 6, 7, 11, 15, 18.

² Plate I, figs. 6, 14, 15, 18.

All the varieties of length, thickness, porosity, solidity, and ornamentation, observed on the septa are represented in the costal structures. As a rule, the costæ are shorter than the septa in transverse section, but there are many exceptions to it, and it is very common to find a rudimentary septum of a high cycle with a corresponding well-developed costa.¹ The projection of the costæ from the wall and the size of the space between them (intercostal space) vary greatly; in some species the costæ are close and form simple prominent ridges, whilst in others they are wide apart, project greatly, and may be covered with great spines, dentations, or serrations. The greater projection of certain costæ, the ornamentation of others, and their correspondence with the cyclical arrangement of the septa, are readily studied in different species.

The costæ do not always project at right angles from the wall, and those that are very long often curve and twist. Whatever may be their form or length, they have sides and a free surface. The sides of neighbouring costæ are frequently joined by the dissepiments of the exotheca, or they may be simply marked by dissepiments which do not stretch across the intercostal space.² The sides are often spined or granulated, and are even perforated in certain species. The variety in the ornamentation of the different cycles of costæ in the same individual is very interesting, and its study is of great use as a secondary method of specific diagnosis.

In many compound corals the costæ of one corallite run into and join those of the neighbouring corallites,³ whilst in others, where the walls are fused,⁴ the costæ abort altogether. There are many species where the costæ are simply rows of granules; in others the rows of granules⁵ become lines of slight elevation, and finally well-developed costæ. The reverse occurs, and well-developed costæ on the outside of a calice often become granular or even become aborted on the wall.⁶

The exothecal dissepiments extend beyond the costæ in some instances, and, as a rule, the costæ are then feebly developed.⁷ The following are some of the most important variations in the structure of costæ. They may be absent or rudimentary, and they may arise on the corallum at various heights from the base. They may be recognised under the following aspects:—Small, large, finely granulated, indistinct, generally indistinct inferiorly, prominent, prominent near the calice only, prominent inferiorly, sub-equal, equal, alternately large and small. As faint ridges, as striæ, moniliform, very thin, perforate, wedge-shaped, flexuous, broad, flat; formed by a series of globules, spines, and granules; wide apart, close, rounded, cristæform, tubercular, largely spined, dentate, alæform, crenulated, striated, verrucose, folded in zigzag, echinulate, long, dichotomous, inclined, &c.

The costæ do not invariably correspond to septa, and are not constantly continuous

¹ Plate IX, fig. 11.

² Plate IX, fig. 7.

³ See 'Descriptions of the "*Thamnastræa*," in 'Brit. Foss. Corals,' MM. Milne-Edwards and J. Haime.

⁴ Plate IV, fig. 11.

⁵ Plate V, fig. 6.

⁶ Plate I, fig. 4.

⁷ Plate V, fig. 2.

with them. It will be noticed that in some species of *Cyathophyllidæ*, and in many Tertiary¹ simple corals, that the external edges of the septa correspond with the intervals between the costæ, and not with those organs themselves. This is not an accidental variation in growth, but is constant in several species.

In some species there are small costæ which do not correspond to any septa; the large costæ are continuous with septa; but these so-called rudimentary costæ simply project externally, and correspond internally with an interseptal space.²

In some corals the epitheca, whilst covering the costæ and hiding them from view, appears to have produced their partial absorption, for above the limit of the epithecal structures the costæ may be seen to be prominent and to be greatly ornamented.³ It may be inferred that in young specimens whose epitheca is not fully developed the costæ would command more attention in the specific diagnosis than is proper, and this has taken place in more than one instance. The costæ may, however, retain all their ornamentation when covered by a very dense and membraniform epitheca, and this peculiarity is generally constant. Occasionally the long spines on the costæ of some *Lithophyllaceæ* project through the epitheca, but in the majority of instances they are included. It is evident that the costæ were well developed before they were covered by the epitheca.

The more prominent the costæ, the more they are exposed to the destructive influences of rolling and of wear and tear; it happens, therefore, that the large cristæform costæ, the long delicate spines on their edges, and the finely granulated dentations, are rarely distinguishable in many fossil species, and their former existence can only be suggested in consequence of scars and raggedness on the surface, or by the preservation of an ornament here and there.

In examining the costal structures the specimen should be placed in several positions and in different lights, for small structural peculiarities are often hidden in the shadows.

Endotheca.—The structure which, stretching from one septum to another, closes more or less the interseptal loculi,⁴—the horizontal processes which, extending from side to side in a corallite, shut out all beneath from communication with above,⁵ and certain exaggerated septal papillæ, which meet in the interlocular spaces and form a system of joistwork,⁶ constitute the *Endothecal Sclerenchyma*.

The first variety, termed by Milne-Edwards and Haime "*Traverses*" or *Endothecal dissepiments*,⁷ characterises many genera; whilst the second, termed by these authors "*Planchers*" or *Tabulæ*,⁷ serves to distinguish a great series of *Madreporaria*. The third variety is seen in the family *Fungidæ*, which it characterises, and the name *Synapticula* is given to it.

¹ 'Ann. Mag. Nat. Hist.,' loc. cit.

² In *Turbinolia Forbesi*, Dunc.

³ Plate I, fig. 16.

⁴ Plate I, figs. 16, 18; Plate IV, figs. 2, 4, 6, 8.

⁵ Plate III, fig. 8, 9, 10, 11.

⁶ Plate III, figs. 1, 2.

⁷ Plate V, fig. 3; Plate I, figs. 15, 18.

⁸ Plate I, figs. 3, 5, 14.

The endothecal dissepiments, greatly developed in some genera,¹ are either rudimentary or quite absent in others;² they are nearly horizontal, inclined and nearly vertical in different species, and they may be concave or convex upwards; moreover, they may either be very numerous in each interocular space or but one or two only may exist.

As a rule, there is no exact correspondence in all the interloculi as regards the distance of the last dissepiment from the upper septal margin. In some species the distance is considerable, whilst in others the dissepiments fill in the interloculi close up to the bottom of the calicular base.

The dissepiment is attached to the septum on either side of the interocular space and to the inside of the wall. Its inner edge is either free or joins another dissepiment, which, not reaching the wall, is carried inward in its growing course, and so with other dissepiments in succession. It results that, according to the convexity and size of the dissepiments, they produce more or less *cellular* or *vesicular divisions*³ in the interloculi.

The dissepiments may be very coarse or the reverse, and in some species they are found of several sizes. The distance between the dissepiments varies, and the cellular condition of the outer part of the interloculi is often very marked. The straight dissepiments do not produce the vesicular appearance. Dissepiments often form a vesicular tissue when tabulæ exist. There are some important genera without dissepiments, and whose species contain individuals whose internal base forms the lower margin of the visceral and interocular cavities.

In some species, a filling-up of the interior of the corallum by a process of thickening of the lower part of the wall and base supplies the place of the endotheca.⁴

The second variety of endotheca, the *tabular*, is recognised by the horizontal direction of the processes,⁵ and by each process being on the same level with regard to the inter-septal loculi. In fact, the *tabulæ* give the idea of passing through septa and everything else in their horizontal course, for they appear to shut out all the space beneath them most perfectly. Their extent varies with the diameter of the corallite, and is influenced by the occasional presence of *vesicular endotheca*⁶ near the wall; but, as a rule, they are attached to the inside of the wall and to the septa: they may be distant or very close, very delicate or very strong, and they are often marked either by depressions or elevations on their upper surfaces. Some tabulæ are not quite horizontal, but curve upwards in the long axis of the corallite, and others are inclined between horizontal series.

In *Axopora Fisheri* (nobis) the great fasciculate columella clearly passes through the tabulæ, and in the genus *Columnaria* the large tabulæ may be broken off the septa, in longitudinal sections, and it may be readily observed that the septa are continuous and that the tabulæ are not their foundation.

¹ Plate V, fig. 3; Plate I, figs. 15, 18.

² Plate I, fig. 15.

³ Plate III, figs. 9, 10, 11.

⁴ Plate I, figs. 3, 5, 14.

⁵ Noticed in many West Indian Tertiary corals.

⁶ Plate IV, fig. 2; Plate III, fig. 16.

The *synapticulæ* are not considered to be endothecal structures by MM. Milne-Edwards and Haime, but their development in some species renders their present classification necessary. In their feeblest development they are papillæ (on opposite septal laminæ), which have coalesced, and thus form a bar across the interocular space, whilst in their greatest they form long ridges between the septa, and they cannot be distinguished from very vertical dissepiments except that they do not tend to close a cavity.

Exotheca.—There are structures resembling endothecal dissepiments between the costæ of some species;¹ in others these sclerenchymatous laminæ—the *exotheca*—extend beyond the costæ and form a more or less cellular envelope to the corallite, by which it is joined to its fellows to form a compound corallum.²

The simplest exothecal dissepiments are stretched horizontally across the intercostal spaces, they generally reach the free edge of the larger costæ, and now and then hide the smaller. They may be inclined or not.

The highest dissepiment, or that nearest the calice, bounds the lowest reflection of the soft tissues, just as the highest endothecal dissepiments bound and form the base of the soft tissues of the visceral cavity.

In some species there are dissepiments between the costæ very high up, and in others much lower down. The distance between the dissepiments, their arched or plane course, their vesicular character, and the presence of vertical laminæ dividing the space between dissepiments into cells, are all seen to vary greatly in different species.

The dissepiments are very feebly developed in most simple corals, and they may be noticed as simple fold-like elevations on the sides of costæ and as forming dimple-shaped depressions on the wall at the bottom of the intercostal spaces in some of the *Turbinoliæ*.

In *Solenastræa* they may be distinguished as forming cells on the wall and between the costæ and as a tissue which extends around each corallite.

The upper surface of the dissepiments is often marked with elevations resembling blunt papillæ.

The genus *Galaxea* has this exothecal cell-growth in excess; it is termed in such an instance *Peritheca*.³

Cœnenchyma.⁴—Some corallites in many compound corals are separated by a very dense sclerenchyma, which is variously ornamented on its free or intercalicular surface. In some species the walls of the corallites are evidently independent of this structure, but in others this is not the case. It would appear that this tissue, which is very cellular in its simplest development and hard and solid in its greatest, is really an *exothecal* structure, and that it is formed by the lowest and reflected layer of the external soft tissues. The costal markings, the granules, spines, monticules, ridges, and depressions, on the surface of the cœnenchyma differ greatly in many species.

¹ Plate I, figs. 11, 18.

² Plate V, figs. 2—5.

³ Plate I, fig. 19.

⁴ Plate IV, figs. 7, 12, 17, 18.

Epitheca.¹—This structure is occasionally seen both in simple and in compound corals; it is the “foot-secretion” of Dana,² and may either be closely applied to the wall of the corallite or may simply cover the costæ, leaving them more or less perfect in their ornamentation. In some simple corals it covers the wall so closely as to resemble a coating of varnish, in others its texture is rough and marked with concentric or encircling ridges, and in a few instances it is marked by chevron-shaped lines. The epitheca may be very thin or very dense, and it may simply cover the base or only reach a short distance upwards from it; or it may cover all the external surface as far as the calicular margin. The dense *epitheca* of some *Montlivaltia* is accompanied by a great diminution in the strength of the wall; this is seen also in many *Rugose* corals. The epitheca of compound corals is rarely ornamented, but is laminate and often readily destroyed. Its preservation in fossils is comparatively rare, and it should therefore not be made of very great classificatory value.

The epitheca develops processes in certain species and only covers the base of others; it is porcellaneous in some, as in *Flabellum*, and pellicular in others, as in *Balanophyllia*. It is membranous, striated, verrucose, marked by growth-rings, shining, rough and partial, in different species.

It is a structure evidently formed after the development of the costæ, and results from a tissue which is a continuation of that which determines the agglutination of the bases and peduncles of certain corals to their supporting earth, stone or rock, or foreign organism.

III.—ANATOMY OF THE SOFT TISSUES.

The membranous surface which covers the calice, supports the tentacles, and is perforated by the mouth, is called the *Tentaculiferous Disc*.³

The opening of the mouth is central, and is either circular or elliptical in outline; it is at the top of a truncated cone⁴ whose base is continuous with the disc and whose height varies according to circumstances. The margin of the opening—the lip—is usually marked by radiating ridges, is very prehensile, and can be moved in different directions. The cone, whose upper extremity is the mouth, varies in its power of protrusion in different species; this is especially great when the tentacles are small and are only arranged at the margin of the disc; and, as a rule, when the tentacular development is considerable the labial protrusion is slight. In some species, such as *Heliastrea cavernosa* and *Lithophyllia Cubensis*, there is a considerable space between the mouth and the tentacles, and these last are feebly developed; consequently the mouth can be so protruded as to form a hollow between its cone and the base of the tentacles.

¹ Plate I, fig. 16.

² Plate IV, fig. 6.

³ Plate II, figs. 4, 9, 11, 10, 13, 14, 16, 17.

⁴ Plate II, figs. 10, 11.

The *ridges* which mark the lips are continued on to this vacant space, and radiate towards the bases of the tentacles.

In some species the moveable mouth and the hollow between it and the tentacles are of more use in obtaining food than the tentacles themselves.¹

The contrary is very evident in *Caryophyllia clavus*² (the *Caryophyllia borealis* of British zoophytologists), and in *Cladocora cæspitosa*.³ In these species the tentacles are greatly developed and extend close up to the base of the cone which is surmounted by the mouth and lips; there is but little of the disc unoccupied, and the power of protrusion on the part of the cone is comparatively slight. Yet it must be observed that when the tentacles are withdrawn, the mouth is capable of being projected further than when they are in full extension.

The lips, the external surface of the cone, and the disc, are covered with cilia. At the marginal extremity of the disc in some species, and scattered over more or less of the whole disc and extending even very close to the labial orifice, in others, are the tentacles.⁴ These organs vary in length and thickness in different species, but each has a base continuous with the tissues of the disc and opening into the upper part of the visceral cavity. Generally terminated by a bulbous swelling, the tentacles are perforated throughout by a delicate canal, and consist of tissues which render them very mobile, contractile, extensile, and more or less prehensile. The external margin of the disc corresponds with the calicular margin; it is separated from it by a very small space, is continuous with the tissues covering the outside of the coral, and in some species has a small fold which covers in the tentacles.

The opening of the mouth, when fully expanded, admits of the columellary surface being seen at the bottom of a shallow cavity; and the sides of this cavity, marked by the continuation of the ridges noticed on the lips and disc, are often protruded through the lips.⁵ The cavity is the stomach, and it is separated from the visceral cavity, which is below or at about the level of a prominent columella, by a faint constriction—the *pylorus*. The stomach is very short and very extensile.

The sides of the cavity are continuous, by means of the lips, with the outside of the disc; they are formed by the same tissues, but the tegumentary layer of the disc is altered and becomes the superficial layer of the mucous membrane of the stomach.

The ridges already noticed on the lips, disc, and stomach, correspond on the under side of the disc and outside of the stomach with *mesenteric folds*.

The pylorus opens into the visceral cavity, whose upper boundary is the lower surface of the tentaculiferous disc, and it therefore is clear that the stomachal membranes con-

¹ Plate II, fig. 10.

² Plate II, figs. 7—11.

³ Plate II, fig. 4.

⁴ Plate II, figs. 4, 7, 11, 12, 13, 14, 17, 18, 19, 20.

⁵ The ridges are seen in Plate II, figs. 11, 13, 14.

tinued over the pylorus are reflected, upwards again, outside the stomach to cover the lower surface of the disc. Here, moreover, they form the *mesenteric folds*, upper attachment is to the under surface of the disc, and whose inner is in part to the ridges of the lips and the corresponding structures on the outside of the stomach. There are openings between these mesenteric folds corresponding with the bases and canals of the tentacules. The pylorus exists more in name than in reality, for the passage into the visceral cavity is large and easily passed. Around the lower margin of the pylorus, and attached where the ridges already alluded to end, are the free edges of the mesenteric folds and a *tubular structure*.¹ There is a distinct numerical relation between the development of the ridges, mesenteric folds, tentacules, septa, and pali.

If the disc were removed from the subjacent corallum by cutting the membrane which is continued from below upwards to its margin, and the pylorus were pulled upwards, the septa, pali, columella, wall, and dissepiments, would be exposed to view, covered by soft tissue; in other words, all the boundaries of the visceral cavity except the upper would be seen.

The upper boundary—the under surface of the excised disc—presents a series of radiating soft folds, separated *by intermesenteric spaces*, which are perforated by foramina, continuous with the tentacular canals. The pali and septa are developed in these spaces, and hence it is that the tentacules over these hard parts appear to grasp them by their bases.

The visceral cavity is bounded below and externally by the tissues covering the inside base, the wall, and the dissepiments which close in the calicular fossa, as the case may be.

The cavity is divided by the septa and mesenteric folds into a series of *radiating fissures*, which may be recognised in the dead specimen by means of the interseptal loculi.

The absence of the columella and of endothecal dissepiments infers a large visceral cavity, and it may be readily understood that a coral developing endothecal dissepiments rapidly will have a short visceral cavity, for the newest dissepiment bounds the calicular fossa inferiorly.

The sea-water and its minute organisms would pass into the mouth, through the stomach and pylorus, and would enter between the mesenteric folds into one of the perivisceral fissures of the great visceral cavity, and the water passes out again through the tentacular canals.

The under surface of the disc is continuous with the soft tissues covering the septa and wall (internally) by their direct continuation upwards. The contiguity of the tissues covering the costæ and outer part of the *wall* with the outer rim of the *disc* has been noticed.

The *disc* thus constituted is, when the polype is well nourished and lively, slightly

¹ Plate II, fig. 2.

elevated above the calicular margin; its tentacles are stretched out and overlap the hard parts, whilst the conical mouth is barely visible. Under other circumstances the disc is contracted, the mouth open, the tentacles more or less retracted, and the outer part of all the septa is visible through the translucent tissues.

In certain "serial" corals, such as *Diploria cerebriformis*,¹ the edge of the disc gives exit to *prehensile cirrhi*, and these organs are to be seen projecting from the rim of the disc in *Caryophyllia clavus*.² They are very thread-like, and have prehensile powers. The microscopic anatomy of these cirrhi has not been studied.

The tubular structures, "*cordons pelotonnés*," which are attached to the juncture of the mesenteric folds with the pylorus,³ float about in the visceral cavity, and especially near the inner margin of the smaller septa; their lower end is unattached and often rises on to the top of the columella. These tubular structures are very much twisted, hollow, and contractile, and are covered with cilia. They often contain ova. The relation between the mesenteric folds and these tubular structures in the physiology of reproduction requires further examination.

The hard parts of the corallum are included in and nourished by soft tissues.⁴ This is invariably the case in every species up to a certain period of growth. In some it is true during all the stages of their development, whilst in many species only the upper part of the corallum is in contact with the soft tissues after a certain height has been attained.

Thus, in the *Caryophyllia clavus* the outside of the corallum is covered by soft tissues from its narrow base to its calicular margin and the inside also. The wall, the costæ, the septa, the pali, and the columella are covered by a membrane which sends processes into their dense structure. The nutrition, growth, and in some instances the absorption of the hard tissues, are carried on by means of the membrane and those processes, and so long as the hard and soft parts are in contact, the first cannot be said to be independent of the latter.

In corals where the growth is accompanied by the formation of dissepiments in the interloculi, the whole of the interior of the corallum below the dissepiments nearest the calice, is not in contact with the soft parts; it has ceased to be nourished by them, and it is to all intents and purposes dead. Moreover, the external membrane does not descend for any considerable distance below the calicular margin, and the lower parts of the costæ and wall are as dead as the lower parts of the interior of the corallum. This is the case in most of the large and luxuriantly growing compound corals, and only a few lines on their surface may be living, the rest is dead. Each portion of the *endotheca*, as it springs from the septa or wall, is formed by the fine membrane and is included in it; as growth proceeds the curved, straight, horizontal, or vertical dissepiment is lined on each surface

¹ Plate II, fig. 17.

² Plate II, fig. 11.

³ Plate II, fig. 2.

⁴ Plate I, fig. 17, diagram.

by the soft tissue, but as the dissepiment closes off the space beneath it the inferior layer of membrane is absorbed, and finally is no longer to be noticed. This is the case with the *exothecal* structures also; the exothecal layers, the cœnenchymal cells, and the perithecal cells, are formed by the membranes, and as the cells become closed the included membrane is absorbed. All the granular and spiniform ornamentation of the sclerenchyma is also formed in the soft tissues, and the more or less dense *epithecæ* results from the development of a tissue from the base of the corallum.

This last is called the foot-secretion, and covers the results of the growth of the membrane which develops the wall and costæ.

The deposit of earthy and inorganic matter in living corals is not, then, a simple concretionary process, but is essentially a vital one; it follows certain laws, and its extent and amount depend on the nutrition of the individual. When the influence of the soft tissue is no longer felt the hard parts become harder and denser and are subject to various changes in their mineral condition.

In those corals whose calices are not separate, but are continuous and running into series, the tentacles, as a rule, are small, numerous, and are often partly hidden by a ridge of membrane.¹ There are several mouths to the elongated and tortuous calices.

The microscopic structure of the soft tissues of the *Sclerodermic Zoantharia* has been ably studied by many observers, and the following extract from the description of the soft parts² of *Cladocora cæspitosa* by the late M. Jules Haime contains information sufficiently exact for the present purpose.

“The surface of the corallum is more or less convex. When extended the polypes touch each other with the extremity of their tentacles, and when they are seen from above there is no interval between them. The tentaculiferous disc is never more than two or three millimètres above the calicular margin of the polyperites, and the lateral and inferior continuation of the disc only descends one or two millimètres below the margin. When a polyperite is cut longitudinally it will be readily observed that the soft tissues are not prolonged much deeper internally in the visceral chamber, so that in the adult coral, which is usually several centimètres long, only about five or six millimètres of its upper part are covered by the soft tissues. This limited portion is bounded inferiorly by the uppermost of the series of horizontal dissepiments. All the rest of the corallum appears to be dead, and is ordinarily covered with *Serpulæ* and *Nullipores*.

“When the tentacles are fully extended, the diameter of the circle formed by their extremities is about one and a half times as large as that of the calice. The margin of the calice is usually visible on account of the transparency of the soft parts covering it.

“The tentaculiferous disc is horizontal, but towards the middle of it there is a slight

¹ Plate II, figs. 14, 16, 17.

² ‘Hist. Nat. des Corall.,’ vol. ii, page 589 *et seq.* See description of Plate II.

concave track, and the mouth projects in the form of a more or less oblong truncated cone. There are from sixteen to eighteen internal folds, faintly shown, however, on the rim around the mouth.

“The tentacles are of the same number as the septa whose summits they envelope, and there are always from thirty-two to thirty-six. They are evidently equal in size and in length. Their length is nearly equal to that of the diameter of the corallite. They are elongated, swelling a little above their insertion, and then becoming very slender as far as their free extremity, which is terminated by a small knob-shaped enlargement.

“The polypes can contract to various extents. Several very characteristic movements may be noticed, however. A slight agitation of the surrounding water or the contact with small particles, suffices to cause a shortening of some or all of the tentacles, although the disc does not alter its shape or position.

“When the exciting cause acts more decidedly and continuously, the shortening of the tentacles increases, the disc retreats, and the protractile mouth elongates in advance of the calice. This state of things is very usual in disturbed or decomposing water. If the animal itself is shaken or is touched, it retracts its disc into the calicular fossa, and nothing is to be seen of the soft parts but some small elevations corresponding with the tentacles. Finally, a violent shock or a prolonged irritation produces so complete a retraction that the tentacles disappear completely, and the white colour of the septa is seen. The calice looks as if it were dried, and there is only a light brown tissue in the interseptal loculi. In this last case the water which usually distends the tissues has been gradually expelled, and they are so reduced in volume that they are readily withdrawn into the interseptal and columellar spaces.

“The disc and the tentacles are of a transparent brown colour, and when the sun shines, a brilliant green tint may be seen within the tentacles. This coloration evidently depends in some instances upon the light. But it is necessary to remark, that the primary and secondary tentacles and those of the third cycle which are flanked by quaternary are those which show this green tint in their insides. The peculiarities of these tentacles coincide with the presence of pali, which are situated beneath and within them.

“When the mouth opens, as it often does when the polype is semi-retracted, the papillæ of the columella are visible. The stomach is very short, and is almost reduced to a rim, which is confounded with the lips.

“The tentacles are not smooth, but are covered with a multitude of small wart-shaped prominences, of a transparent white colour; they are equal in size, and measure a tenth of a millimètre in width. The terminal bulb presents a narrow central canal, which communicates both with the tentacular cavity and with the external medium. The three layers of tissue which constitute the tentacles have the same general characters as in the *Actiniæ*, but the four layers of the tegumentary covering are not to be detected.

“1. The first envelope is quite transparent, and is composed principally of nematocysts of

three dimensions, those of medium size being the commonest; also, of very simple cells, either irregular in shape, or oblong or pyriform; and of small rounded and transparent globules, which form the innermost layer.

“There are no cells in the external tegument which produce the colour of the polype. The white warts which project on the surface are made up of a mass of large, transparent and elongated vesicles.

“The nematocysts, which form the most important part of the integument of the tentacles, are slender and cylindrical, one of their extremities being smaller than the other.¹ They contain a thread regularly rolled up as a spiral, and which near the large end terminates in a straight and central portion. The thread when unrolled is about two tenths of a millimètre in length. The nematocysts are perpendicular to the tentacular surface, and their large end is the most external; the internal thread makes its exit by this extremity.

“The terminal bulb² of the tentacles is almost entirely composed of these filiferous capsules; there are two other kinds in it unlike those just described, some larger and stouter, and others much narrower and more slender. The first are elliptical, slightly attenuated at one of their ends, and they contain a thread rolled into a slack spiral. This thread shoots out from the small end of the cell. The remaining nematocysts do not appear to have a proper cell-wall; they are cylindrical, slightly smaller at both ends, and very slender; they are formed by a filament very closely rolled into a dense spiral, which unrolls itself like the wires used in some elastic clothing.³

“The structure of the skin is the same over the whole surface of the polype. The nematocysts of the second size are the most common. A certain number of those of the largest size are found in the stomacho-buccal rim. The cilia are very distinct at this spot, and around the disc also, although they are very delicate; they are rare and feeble on other parts of the polype; they are very indistinct on the tentacles, and are wanting on the bulb.

“2. The middle or muscular layer is formed by transverse and vertical fibres which are excessively slender and sparsely distributed. Very thin oblique muscular fibres may be seen at the bases of the tentacles.

“3. The internal membrane is formed by a layer of transparent cells tolerably adherent to each other, and by a layer of colour-bearing globules which are spherical or slightly oval in shape.

“It is these cells which give the colour to the polype; they are filled with irregular-shaped grains, of a bright brown colour; they themselves are secreted in certain transparent vesicles, and present the greatest resemblance both in shape, colour, and structure to the globules which float free in the tentacular cavities of young sea-anemones. It is probable they have a corresponding function in their early age. Near the top of the

¹ Plate II, fig. 1.

² Plate II, fig. 3.

³ Plate II, fig. 6.

tentacles these colour-bearing cells are arranged in small irregular groups, but elsewhere they become more numerous.

"The internal membrane lines the interseptal loculi, where its presence is rendered evident by its colour; it is stopped inferiorly by the last sclerenchymatous dissepiments. The mesenteric folds formed by this membrane present a few colour-cells. The folds¹ give attachment to the simple "boyaux pelotonnés" which float in the large interseptal loculi along the smaller septa, and which often show themselves on the columella when the mouth is half open and the polype is slightly contracted. Their walls are almost entirely composed of nematocysts of the largest size, and their surface is furnished with large and strong cilia; they are frequently affected by peristaltic movements, and they are attached to the tentaculiferous disc by strong muscular fibres."

IV.—REPRODUCTION AND MULTIPLICATION.

Ovular Reproduction; Gemmation; Fissiparous and Serial Growth; Reproduction.

The *mesenteric folds* and the twisted *tubular processes*, whose ends are free in the visceral cavity, appear to be the organs which develop the male and female elements.

It would appear that all corals are not bisexual, but the majority are so. Spermatozoa were asserted to exist in the *tubular processes*, but their description tallied with that of the thread-processes of *nematocysts*. Milne-Edwards dispelled this illusion, and the true male elements have been discovered. The presence of ova in the *mesenteric folds* and in the *tubular processes* has been noticed and in the latter position by Michelotti and Duchassaing in large compound corals.² The ova are matured in the folds and processes, and then escape into the visceral cavity, and are expelled through the stomach and mouth. They have some power of active locomotion, and select favorable localities for their resting-place. The young polypes have faint traces of the future sclerenchyma, and grow rapidly when once fixed, provided they are well nourished.

As growth proceeds, the structure of the wall determines the shape of the corallum; and its *simple or compound character is regulated by the particular methods of the multiplication of the individual*. Some corals are always simple or solitary, others for a considerable period, and some for a very short time. The kind of *gemmation* or *budding* determines the massive, dendroid, encrusting, &c., nature of corals.

It appears to be very rare for buds to fall from the parent corallum and to form independent individuals.

By gemmation is meant the development of corallites from the tissues of a parent corallum. A very small patch of the membrane in immediate contact with the sclerenchyma of the parent appears to pucker, and septa are rapidly formed within the enlargement which occurs; tentacles have already appeared, and the small bud proceeds as if it

¹ Plate II, fig. 2.

² Op. cit.

³ Op. cit.

were an independent organism as regards its growth, but its membranes are continuous with those of the parent. In many corals the base of the bud and the visceral cavity of the parent are at first continuous; but in others the membrane reflected over the septa, the margin of the wall, the external surface of the wall or of the base, produces the gemmation.

The gemmation may take place, then, on any part of a coral. It may occur within the calice, on the calicular margin, on any part of the wall between the calice and the base, and it may happen at the base. The direction of the line of growth of the bud has much to do with the future shape of the corallum, and the power of growth of the parent corallite after the development of the bud also.

The parent corallite may not grow after the production of a bud from its external wall; the bud becomes a perfect corallite, and gives origin to a bud in its turn. This repetition may go on, and a corallum results, formed by an ascending series of simple corallites; or the parent corallite may elongate after giving off a succession of whorls of buds which do not in their turn always develop others. The space between the whorls and the individual buds becomes filled up with exotheca and cœenchyma. A dendroid corallum results, as in the genera *Madrepora*¹ and *Stylophora*.

Again, straight cylindrical corallites give off one or two buds, and all continue to grow, passing upwards, the calices keeping on one level, and the corallites being parallel. This determines the massive corals of many *Astræidæ*.

A corallum with geometrical calices whose walls are soldered together buds within the calices;² the parent calice and the bud grow, and the coral both expands laterally and increases in height. This produces a very common form of compound coral.

Certain corals never raise themselves far from the foreign substance they rest upon; the base gives off a bud, which, stolon-like, gives forth others, and all turn upwards slightly.

From these considerations it is evident that there is a necessary division of the gemmation into *calicular*, *basilar*, and *lateral*.

Calicular gemmation takes place from the interseptal loculi near the columellary space, and either midway between it and the wall, or just within the calicular margin. One or more buds may grow at once, and the budding may or may not be fatal to the parent. A pseudo-calicular gemmation is occasionally seen in simple corals which are only oviparous. It is produced by one of the young polypes settling on the parent accidentally, and growing to its detriment.³

The true calicular gemmation is well seen in the simple forms of the genus *Cyathophyllum*,⁴ in a new genus from the Lias (*Lepidophyllum*), and in the genera *Stauria*,⁵ *Isastræa*,⁶ &c.

¹ Plate IV, fig. 18.

² Plate IV, fig. 11.

³ Plate IV, figs. 8, 10.

⁴ Plate IV, fig. 10.

⁵ Plate III, fig. 15.

⁶ Plate IV, fig. 11.

Gemmation from the wall—the lateral form—may occur at the top so as to affect the calicular margin, and at any place between this and the base. The gemmation may be solitary, alternate, whorled, numerous, or irregular; and the parent may or may not grow after the development of the buds.¹

The genera *Cladocora*, *Solenastræa*, *Oculina*, *Lophohelia*, *Madrepora*, *Heliastræa*, *Stylocænia*, *Stylina*, *Astrocænia*, *Stephanocænia*, &c., furnish examples of lateral and marginal gemmation.

The basilar gemmation is especially to be observed in the genera *Rhizangia*, *Astrangia*, *Phyllangia*, and other *Astrangiaceæ*.

Fissiparous growth.—Many corals increase in dimension and become cæspitose, gyrate, laminar, or massive, by a repetition of a fissiparous process in the calice or calices. The general nature of this method of calicular division and subsequent growth may be seen in Plate IV, figs. 12, 13. The calice is fairly bisected through the columella or columellary space by the growth of two or more opposite septa, and the wall appears to curve inwards, whilst the parts on either side grow independently and separate with varying rapidity. The process may be more or less speedily repeated in the new calices, and as they separate and grow upwards they may or may not be enveloped in cœnenchyma.

Very differently shaped corals thus result.

The genus *Dichocænia* offers examples of massive corals where there is fissiparous growth and much cœnenchyma. The genus *Favia* has its fissiparous individuals in close contact, and the species of *Thecosmilia* yield long, dendroid, and cæspitose forms.

Serial growth.²—Corals of the genus *Diploria*, *Latimæandra*, *Rhipidogyra*, *Pectinia*, *Teleiophyllia*, *Thysanus*, *Manicina*, &c., have either faint traces of calices running laterally into each other, or else the septa follow each other in a longer or shorter series, which is sometimes straight, at others twisted. The occurrence of cœnenchyma, and the particular manner in which the “series” may be joined laterally, determine the shape of the corallum. In the *Latimæandræ* the faint traces of calices may be seen. In *Diploria* and *Mæandrina*³ the septa are in series, and form a massive coral; whilst in the *Teleiophylliæ* and *Thysani*,⁴ where there is a long series, the corallum is simple and pedicillate.

Gemmation occurs both in fissiparous and serial corallites.

V.—PHYSIOLOGY.

The ovules of corals are projected from the visceral cavity through the pyloric constriction, the stomach, and the mouth, by the contraction of the tissues of the disc; and the cilia of the cavities assist the transit. Cilia cover the small ovule and move it onwards

¹ Plate IV, fig. 16, 17.

² Plate IV, fig. 14.

³ Plate IV, fig. 15.

⁴ Plate IV, fig. 14.

with the assistance of the currents in the water; when it comes in contact with a hard substance, or rests, out of a current, on soft ground, the base adheres, and the minute tentacular disc is gradually developed, and finally expands. The young polypes are carried here and there; they exercise no volition, and only those which find a fit base upon which to rest live on to maturity. Either the young corallum adheres fixedly through life, or is so buried in mud or sand as to be immovable.

The locomotion of corals, therefore, is confined to the early period of their existence, is more or less passive, and the organs concerned in it are the cilia. The cilia vary in length, and their movement is vigorous; their activity is increased by light, warmth, and a highly aërated pure sea-water.

The adhesion to the foreign substance occurs by means of the outer membrane: if the base of the future corallum is to be small and pedunculate, the membranes at the base grasp some irregularity of the surface of the stone or shell, as the case may be, or envelop the body should it be small. As the hard parts are developed by the inner membranes, they pass around or envelope the substance, and fix the coral permanently. Occasionally, specimens are found with erosions at the base, as if they had suffered a violent rupture from the supporting substance and had continued to exist.

When a broad and flat base occurs, either the membranes and the subsequently developed sclerenchyma fill up the irregularities on the surface of the substance upon which the polype has rested, or are attached to it by a secretion of the epitheca. When corals rest on soft mud or sand, and become immersed, the tentacular disc appears just above the surface, and the body of the coral is very generally found covered by the epithecal membrane and its badly organised calcareous secretion. It is especially these corals that have large lateral growths, large costæ and processes; and they may be broad at the base, or quite the reverse.

The epitheca acts as an anchor and as a sheathing to the coral.

It has already been noticed, that the skeleton of the coral—its sclerenchyma—is developed and nourished by the inner membrane; and the retreat of this membrane, as well as the apparent death of all the hard parts below its level, have been explained. It will be found that the inner membrane permeates the hard tissues, that these are developed as granules in its intercellular spaces, and that, as the granules become hard, close, and solid, the nourishing influence of the membrane gradually ceases. In perforate corals the membrane is always in contact with the reticulate sclerenchyma, and the interiors of adjacent corallites are constantly in mutual relation.

Considering the weight of many individual corals, and the tenuity of the soft parts, this development of sclerenchyma is very wonderful. It must be remembered, that in many large compound corals only the few upper lines of the corallites are really nourished by the soft parts; all the rest has been gradually developed and left by them.

The density of the sclerenchyma differs more in species than in individuals, and size has nothing to do with it. As a rule, very quickly growing corals are less dense than

others, and the tissues in contact with the membranes are the least resisting. The calcareous and other salts which form the sclerenchyma are derived from the matters assimilated by the coral during its digestive and respiratory processes; their deposition is a vital and not a mechanical process, and its amount is regulated by those conditions which affect the general nutrition of the individual.

The following analyses of recent corals are selected from those made by Silliman:¹

	Porites.		Madrepora.		Pocillopora.		Mæandrina.		Astræa.		(Heliastrea?)
Carbonate of lime	95·84	...	94·807	...	94·583	...	93·559	...	96·471	...	91·782
Phosphates and Fluorides...	2·05	...	0·745	...	1·050	...	0·910	...	0·802	...	2·100
Organic matter	2·11	...	4·448	...	4·397	...	5·536	...	2·727	...	6·118

The fluorides, phosphates, &c., yielded the following results (per cent. of their precipitate) in three examinations.

	1.		2.		3.
Silica	22·00	...	12·5	...	8·70
Lime	13·03	...	7·5	...	16·74
Magnesia	7·66	...	4·2	...	45·19
Fluoride of calcium	7·83	...	26·34	...	0·71
Fluoride of magnesium...	12·48	...	26·62	...	2·34
Phosphate of magnesia...	2·70	...	8·0	...	0·34
Alumina and Iron	16·00	...	14·84	...	25·97
Oxide of iron	18·30				

Silliman arrived at the following conclusions respecting the proportions of the phosphates, fluorides, and other salts:—"Fluorine is present in much larger proportion than phosphoric acid. The silica exists in the coral in its soluble modification, and probably is united to the lime. The free magnesia existed as carbonate, and was thrown down as caustic magnesia by the lime-water."

The dead and living tissues are liable to be perforated by parasitic borers; and the surface of the coral below the soft tissues is often covered with Bryozoa, Serpulæ, &c.

The inner membrane develops the buds, and it has an absorbing as well as a depositing power.

Food is obtained by living corals through the agency of the tentacles, the spiral threads, the cilia of the disc, and the lips. It consists of Animalcula, small Crustacea, the ova of Mollusca, and the spores of Algæ and smaller marine plants. Myriads of organisms may be seen in every small glass of water taken from the tropical seas, and the growth and nutrition of the coral-polypes can be readily accounted for.

¹ B. Silliman in Dana's 'Structure and Classification of Zoophytes,' Appendix, p. 124 *et seq.*

The *nematocysts* of the tentacles¹ and of the general surface are the destroying weapons; their missiles paralyse and slay, whilst the spiral threads envelope and kill as well. The spiral threads are observed in the corals with "serial" calices especially,² and the tentacles are not well developed in those species. The threads appear at the calicular margin, and have openings through which they pass to and fro from the visceral cavity. They are sometimes noticed in simple corals with well-developed tentacles.³

Anything destroyed by the nematocysts of the tentacles, or killed by the spiral threads, either falls on to the disc, or is passed on to the mouth directly and without the agency of the cilia. The cilia are especially useful in passing small bodies towards the lips; and these, when protruded, are moved in all directions seeking food.

Once within range of the lips, the food is grasped by their sphincter and passed into the stomach.

The movement of the tentacles and of the lips is produced by the contraction of the second or muscular tissue. All the tissues are very excitable, and contractions are readily produced by irritation; but the muscles act with a remarkable coordination, considering the absence of the organs of vision and of all nervous structures.

The stimulus of light acts very decidedly, so does that of heat, and direct contact produces that series of changes which has been described by M. J. Haime.

The stomach dissolves more or less of what goes into it, and passes the solution into the visceral cavity through the pylorus, whilst the fæces are returned and rejected. No acid reaction has been obtained from the stomachal membrane. Much water passes through the stomach and into the visceral cavity.

The visceral cavity receives the primarily assimilated food and the water which passes through the stomach; all this is brought in contact with the irrigatory system—with the tissues lining the interloculi covering the septa, &c., with the mesenteric folds and the tubular processes, as well as with the inferior surface of the disc and the bases of the tentacles. Finally, this watery medium kept in agitation by the cilia of the visceral membranes is now and then expelled through the tentacular orifices. A process of absorption goes on, and the results of secondary assimilation appear to be the deposit of the sclerenchyma and the nutrition of the soft tissues.

Doubtless, the external tissues with their nematocysts have a power of retaining and more or less absorbing nourishment without the process of digestion.

The respiration of corals appears to be carried on by the tentacles, the membrane lining the intermesenteric spaces—the irrigatory system, and by the general surface.

¹ Plate II, figs. 1, 3, 5, 6, 7, 8.

² Plate II, fig. 17.

³ Plate II, fig. 11.

Well-aërated water of a certain temperature and containing minute organisms is absolutely necessary for the nutrition and respiration of corals; and mud and sediment held in suspension by brackish water, or by water very slightly saline, are very noxious.

Corals soon die when exposed to such adverse influences; and it is probable that the contractions which are noticed on some simple forms are due to periods when nourishment was scarce and the sea-water impure.

Corals are often phosphorescent; and this is very constantly observed when they have been removed from the sea and allowed to drain away on stones.

There are no special structures in the mesenteric folds which account for the process of absorption, and the method of the development of the male and female elements of generation in them is not satisfactorily determined. The tubular processes allow the ova to escape, and the ciliary motion of the visceral cavity tends to their ejection. The generation of corals is said to require a temperature of not less than 75°; but it must be remembered that very temperate seas have their corals, and that the coast of Norway and of Scotland abounds with them.

Without entering into the question of the geographical and bathymetrical distribution of corals, it may be safely determined that the perforate corals are the most rapid growers, and have the largest amount of soft tissues; they are usually found where the sea is the best aërated and full of organisms, just as some of the most solid of the aporose corals are to be found in calm water and at great depth.

It is the comprehension of the stomach, pylorus, mesenteric folds, and tubular processes within one cavity that distinguishes true *Madreporaria* from the *hydroid Acalephs*. The tabulate corals have been classified amongst these last, but upon insufficient data. Whenever the polype of a tabulate coral is proved to have its digestive and reproductive organs in separate cavities, then the views of Agassiz will be justified, but not till then; the tabulæ are not necessarily calicular bases, for they may often be separated from the continuous septa and columellæ.

VI.—CLASSIFICATION.

In examining a fossil coral, attention must be first of all paid to the structure of its wall and septa. It must be determined whether the first is aporose,¹ or, on the contrary, perforate,² and whether the septa are assignable to systems of cycles which follow the disposition of the rugosa or not. Should there be a tubulate structure of the wall and a rudimentary condition of the septa, it should be noted. Finally, the existence of horizontal tabulæ in the endotheca³ must be ascertained.

¹ Plate I, figs. 1, 2, 3, 4, 14, 15.

² Plate III, figs. 3, 4; Plate IV, fig. 18.

³ Plate III, figs. 9, 10, 11, 16.

There is a vast difference between the economy of a coral with imperforate and a coral with porose walls, and a method of diagnosis arises from it. The aporose and perforate sections are at once natural and easily distinguished.

The horizontal tabulæ may be found in perforate as well as in aporose corals, but the absence of vesicular endotheca and of the usual endothecal arrangements may be so marked that a section can be very fairly marked off. Nevertheless, the gradation of dissepiments into horizontal tabulæ¹ is witnessed in many *Rugosa*, and is not feebly marked even in some corals of the section *Aporosa*.

The tubulate wall and defective septa offer materials for a doubtful section, for they are very closely matched by some aporose forms.

The *Rugosa*² are so peculiar in their septal arrangement that, as a rule, they are distinguished at once; but their diagnosis will be carefully elaborated in a future page.

When the *section* of a coral has been determined, the existence or deficiency of endothecal structures becomes diagnostic. The existence of endotheca refers very definitely to the nutrition and growth of the species, and is readily discoverable.

The method of multiplication, the existence of fissiparous or serial calices, and the independence or the soldered condition of the corallites, must be then noticed.

The existence of pali and the nature of the septal arrangement must be made out, and the absence or presence of a columella determined. The nature of the columella, the shape of the calices, the size and ornamentation of the septa and costæ, must be examined, and the plain or incised condition of the septal margin decided. The existence of exotheca, cœnenchyma, peritheca, and epitheca is to be discovered, and the peculiarities of the structures noticed. The height and breadth, and the habit of the coral should be estimated. There are, then, many data for the foundation of a classification; and the following tables have been drawn up of that of the genera which are most likely to be found in the British Secondary and Tertiary rocks.³

¹ Plate IV, fig. 2.

² Plate III, figs. 15, 18, 19, 20.

³ The tables have been selected from the 'Hist. Nat. des Coral.,' Milne-Edwards and Jules Haime, and have been altered where requisite.

DIAGNOSTIC CLASSIFICATION.

ZOANTHARIA SCLERODERMA (MADREPORARIA), whose visceral chamber is	<div> <div>open throughout, or more or less divided transversely by endotheal dissepiments.</div> <div>The septal structures</div> </div>	<div> <div>well developed; the sclerenchyma</div> <div>rudimentary</div> </div>	<div> <div>compact</div> <div>perforate</div> </div>	Section—	
				<i>Aporosa</i> .	
				"	<i>Perforata</i> .
				"	<i>Tubulosa</i> .
	subdivided into stages by tabulae.	rudimentary, and of the hexameral type	"	"	<i>Tabulata</i> .
	Septal structures	well developed, and of the quaternary type	"	"	<i>Rugosa</i> .

SECTION I. 1. <i>Madreporaria aporosa</i> , having the interseptal loculi	<div> <div>perfectly free and open.</div> <div>Septa</div> </div>	<div> <div>formed by two laminae</div> <div>formed by three laminae</div> </div>	<div> <div>becoming obliterated from below upwards</div> <div>not becoming so, but being simply partitioned off by endotheca.</div> </div>	<div> <div>A distinct coenenchyma surrounding the coral-lites</div> <div>No coenenchyma</div> </div>	Family—	
					1.	<i>Turbinolidae</i> .
					2.	<i>Dasmidae</i> .
					3.	<i>Oculinidae</i> .
					4.	<i>Stylophorinae</i> .
					5.	<i>Astræidae</i> .
					6.	<i>Fungidae</i> .

FAMILY 1. <i>Turbinolidae</i>	<div> <div>with pali</div> <div>without pali</div> </div>	Sub-Family—	
		1.	<i>Caryophyllinae</i> .
		2.	<i>Turbinolinae</i> .

<p><i>Sub-Family.</i> <i>Caryophyllinæ</i>, having</p>	<p>pali before one cycle. The wall</p>	<p>more or less elevated and naked. The columella</p>	<p>with its surface chioracée; pali</p>	<p>broad</p>	<p>Genus—<i>Caryophyllia</i>.</p>
	<p>horizontal and covered with epitheca. Columella</p>	<p>with a papillary surface</p>	<p>lamellar</p>	<p>narrow and tall</p>	<p><i>Bathyocyathus</i>.</p>
<p><i>Sub-Family.</i> <i>Turbinolinæ</i>, having the wall</p>	<p>pali before more than one cycle. The columella</p>	<p>fascicular. The pali</p>	<p>wanting before the septa of the last cycle. The coral-lite</p>	<p>fixed or subpedicellate. The wall</p>	<p><i>Brachyocyathus</i>.</p>
			<p>naked. The base</p>	<p>narrow</p>	<p><i>Discoocyathus</i>.</p>
			<p>with epitheca</p>	<p>broad</p>	<p><i>Cycloocyathus</i>.</p>
			<p>existing before all the septa. The corallite free and discoid</p>	<p>with epitheca</p>	<p><i>Trochocyathus</i>.</p>
					<p><i>Paracyathus</i>.</p>
<p>FAMILY. <i>Dasmiæ</i>.</p>					<p><i>Thecoocyathus</i>.</p>
					<p><i>Leptocyathus</i>.</p>
<p>FAMILY. <i>Oculinidæ</i>, with unequal septa.</p>	<p>naked or with a partial epitheca. The columella</p>	<p>styliform</p>	<p>lamellar</p>	<p>styliform</p>	<p><i>Turbinolia</i>.</p>
	<p>with a pellicular epitheca. Columella</p>	<p>wanting</p>	<p>never essential, wanting, or partly parietal</p>	<p>never essential, wanting, or partly parietal</p>	<p><i>Sphenotrochus</i>.</p>
<p>FAMILY. <i>Oculinidæ</i>, with unequal septa.</p>	<p>Pali before several cycles of septa. The columella</p>	<p>papillary</p>	<p>styliform</p>	<p>styliform</p>	<p><i>Smitotrochus</i>.</p>
	<p>No pali. Columella well developed and spongy</p>	<p>styliform</p>	<p>styliform</p>	<p>styliform</p>	<p><i>Flabellum</i>.</p>
<p>FAMILY. <i>Oculinidæ</i>, with unequal septa.</p>					<p><i>Dasmia</i>.</p>
					<p><i>Oculina</i>.</p>
<p>FAMILY. <i>Oculinidæ</i>, with unequal septa.</p>					<p><i>Synhelia</i>.</p>
					<p><i>Diplohelia</i>.</p>

FAMILY. <i>Astreidae</i> , with the septa	smooth or very slightly granular on the free margin	<i>Eusmilinae</i> (Sub-family).	Corallites simple Corallites aggregated simple or fissiparous, forming a caespitose bush or a linear series; more or less confluent aggregated; multiplication by budding; } corallum massive; calices rarely in series }	(Division)	<i>Trochosmilinae</i> <i>Stylinaceae</i> . <i>Lithophyllaceae simplices</i> . — <i>caespitosae</i> . — <i>maandroides</i> . <i>Astreaceae</i> . <i>Faviaceae</i> . <i>Cladacoraceae</i> . <i>Astrangiaceae</i> .
	more or less dentate, serrate, and ragged	<i>Astreinae</i> (Sub-family), with the corallites	corallites free by their walls; multiplica- tion by budding }		
			” ; reproduction by basilar stolons		
DIVISION. <i>Trochosmilinae</i> , having the epitheca	rudimentary or wanting. Endothecal dissepiments	very abundant. The costæ simple, and no columella	The columella { spongy none }	Genus— <i>Trochosmilina</i>.	. . . . .
	membraniform and complete. The columella		{ lamellar styliform . . . . . }		. . . . .
<i>Stylinaceae</i> , with the corallites united by their costæ. The columella	styliform. Calicular margins free and circular rudimentary or none. { Calicular margins free and circular Calicular margins hidden by the septo-costal rays . . . . . }				. . . . .
					<i>Stylinæ</i> . <i>Cryptocenia</i> . <i>Conexastreæ</i> .
<i>Lithophyllaceae simplices</i> , with a strong and membranous epitheca; no columella					. . . . .
					<i>Montivallia</i> .

<i>Lithophyllaceæ cæspitoseæ</i> , having their corallites	{ <div> free laterally, or united in series whose walls are never completely soldered. </div> <div> rudimentary or none. Costæ </div>	{ <div> simply granular and distinct. </div> <div> The columella </div>	{ <div> rudimentary or none; mural "collettes" exist. </div> <div> well developed, "no collettes". </div>	<i>Calamophyllia</i> . <i>Rhabdophyllia</i> .
	{ <div> well developed and </div>	{ <div> confounded with the wall. The septa </div> <div> calicular gemmation very decided; corallites short </div>	{ <div> numerous, with subspiniform teeth </div> <div> few, with feebly developed teeth </div>	<i>Thecosmilia</i> . <i>Cladophyllia</i> . <i>Lepidophyllia</i> .
<i>Lithophyllaceæ mæandroides</i> , with the	{ <div> corallites massive; the series soldered by their walls, which form simple elevations. </div>	{ <div> Series radiating </div>	{ <div> Series radiating </div>	<i>Stelloria</i> .
	<i>Faviaceæ</i> , having the septa non-confluent. Corallites united by costæ and exotheca.	{ <div> rudimentary. The corallites united by exotheca </div> <div> oblique internally, and little or not at all confluent ex- ternally; teeth of septa </div> <div> more or less horizontal, and being confluent externally. </div> <div> Endotheca </div>	{ <div> limited </div> <div> forming series </div>	<i>Solenastrea</i> . <i>Isastrea</i> . <i>Latimæandra</i> . <i>Plerastrea</i> . <i>Thamastrea</i> . <i>Stylocænia</i> . <i>Astrocerenia</i> . <i>Elyastrea</i> .
<i>Astræaceæ</i> , having the calicular margins	{ <div> free. Multiplication usually by extra-calicular gem- mation. The costæ </div> <div> united. Corallites increas- ing by superior and mar- ginal and intra-calicular gemmation. Septa hav- ing their edges </div>	{ <div> Columella styliform. </div>	{ <div> well developed; walls compact </div> <div> rudimentary; septo-costal rays confluent </div> <div> Projections on calicular interspaces </div> <div> No projections </div>	<i>Astræaceæ</i> , having the calicular margins
	{ <div> united; corallites free inferiorly; an epitheca </div>	{ <div> united; corallites free inferiorly; an epitheca </div>	{ <div> united; corallites free inferiorly; an epitheca </div>	<i>Goniocora</i> .
<i>Cladocoraceæ</i> , without pali				

Astrangiaceæ, with a complete epitheca *Cryptangia*.

SECTION.

Fungidæ,

having the wall or common plateau

{ porose, and usually echinulate

{ neither porose nor echinulate

Sub-family—*Funginæ*.

„ „ *Lophoserinæ*.

Funginæ,
with septa

{ formed by laminae nearly continuous; the wall distinct and granular

{ subporose; wall indistinct; corallites

{ simple

{ compound

Genus—*Microbacia*.

„ „ *Anabacia*.

„ „ *Genabacia*.

Lophoserinæ,
having the corallum

{ compound;
the corallites

{ rather tall; "collines" independent of the common plateau;

{ very short; calices not separated by collines, but

septa numerous; epitheca complete *Comoseris*.

„ „ *Protoseris*.

Section of
Madreporaria perforata,

{ wall well developed and simply porous; principal septa lamellar

{ whole corallum formed by reticulate sclerenchyma; septa as trabecular processes

Family—*Madreporides*.

„ „ *Poritides*.

Madreporides

whose corallum has

{ not an independent coenenchyma

{ an abundant coenenchyma. The six primary septa

{ unequally developed, two larger than the others, *Madreporinæ*.
equally developed *Turbinarinæ*.

Sub-Family—*Eupsammineæ*.

<i>Eupsammia</i> , having the corallum	{ simple, with base largely fixed. discoid, with a horizontal wall compound; epitheca rudimentary; columella	{ distinct and well developed { by budding generation { by fissiparity rudimentary, or none	{ .
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Amongst the Corals with tabulæ, the genus *Axopora*¹ may be distinguished by its reticulate sclerenchyma, its defective septa, and its large fasciculate columella.

Amongst the rugose Corals, the genus *Holocystis*² may be recognised by its lamellar endotheca, well developed septa and costæ, and its styliform columella.

¹ *Axopora* in the Brockenhurst and Bracklesham beds.

² *Holocystis* in the Lower Greensand.

VII. CORALS FROM THE TERTIARY¹ FORMATIONS.

I. *Corals from Brockenhurst and Roydon.*

THE fossiliferous bed at Brockenhurst in Hampshire was discovered during the formation of a railway; it was diligently examined, and it has produced some most interesting mollusca and corals.

The molluscan fauna has much in common with those of the beds in Germany about Magdeburg, Bernburg, Aschersleben, Egeln, Helmstädt, and Latdorf,² and with those of the strata at Tongres, near Liége. Moreover, some of its most characteristic species are found in the Middle Headon beds at Colwell Bay and at Whitecliff Bay, in the Isle of Wight.³

The Brockenhurst bed lies immediately upon a freshwater formation,⁴ the fossils of which are specifically identical with those of the freshwater beds of the Lower Headon; and it is covered by unfossiliferous sands.

The fossils from Roydon probably came from a well.

Corals are not found in the Middle Headon beds, but they abound at Brockenhurst; and it may therefore be admitted that the strata at the latter locality are the purely marine and oceanic representatives of the former.⁵

The specimens of fossil corals from Brockenhurst are tolerably perfect; they are generally covered with a red argillaceous sand; and they often contain selenite and sulphide

¹ It is necessary in using the terms "Tertiary," "Eocene," &c., to remember that there has been a constant and gradual development of "species" from the first appearance of life on the globe to the present day, and that the terms are only useful as parts of a scientific nomenclature. There is only an arbitrary distinction to be made between any of the successive formations and systems. Hence I have felt very disinclined to term the Brockenhurst beds Lower Oligocene, although they are clearly the equivalents of the German beds so called by Beyrich, and of the Tongrien Inférieur of Dumont.

² Beyrich, 'Ueber den Zusammenhang der Norddeutschen Tertiärbildungen, zur Erläuterung einer geologische Uebersichtskarte; Abhandl. der K. Akad. der Wissenschaften zu Berlin,' 1855.

Römer, in Dunker's 'Palæontographica,' 1862, 1864; Reuss, "Zur Fauna des Deutschen Oberoligocäns," 'K. Akad. der Wiss.,' Nov. 1864.

³ Von Koenen, "Oligocene Deposits," 'Quart. Journ. Geol. Soc.,' Dec., 2nd 1863. (Mr. F. Edwards' researches formed the basis of this paper.) F. Finch, Dr. Sc., has assured me of the truth of this statement from the results of his personal observation.

⁴ Von Koenen, *op. cit.*

⁵ 'Mem. Geol. Survey Great Britain,' on the "Tertiary Fluvio-marine Formation of the Isle of Wight," by Edward Forbes, edited by R. Godwin-Austen, F.R.S., and others, 1856. 'Mem. Geol. Surv.,' "The Geol. of Isle of Wight; Explan. Sheet 10," by H. W. Bristow, F.R.S., 1862. These publications contain admirable and exhaustive descriptions of the Headon series.

of iron. Many have been rolled ; and in all the original carbonate of lime of the sclerenchyma has been but slightly altered.

FAMILY—*ASTRÆIDÆ*.

SUB-FAMILY—*ASTRÆINÆ*.

Tribe—*ASTRÆACEÆ*.

Genus—*SOLENASTRÆA*.¹

The generic characters of the *Solenastrææ* are as follows :²

The corallum is usually massive, convex, cellular, and light : the corallites are long, and are united by a well-developed exotheca, and not by the costæ, which are never large enough to come in contact with those of neighbouring corallites. The costæ are always more or less rudimentary. The calicular margins are free and circular : the columella is spongy, and usually but feebly developed. The septa are very thin, and are formed by well-developed laminæ : their margin is dentate, and the lowest teeth are the largest. The endothecal dissepiments are simple, numerous, and close. The gemmation is extracalicular.

The species already recorded have been separated into those with rudimentary and those with distinct columellæ,³ but they are all well and easily distinguished from the six forms about to be described.

1. *SOLENASTRÆA CELLULOSA*, *Duncan*. Pl. V, figs. 1—7.

The corallum is rather short, and appears to increase in breadth : its upper surface is irregular, and covers more space than the lower.

The corallites are inclined, distant, parallel, and are connected by a cellular exotheca which here and there forms a denser connecting tissue.

The calices are unequal in size and irregular in outline ;⁴ they project considerably above

¹ 'Compt. Rend. de l'Acad. des Sc.,' vol. xxvii, p. 494, 1848. Milne-Edwards and J. Haime.

² 'Hist. Nat. des Corall.,' vol. ii, p. 495, Milne-Edwards et J. Haime.

³ Edwards and Haime, op. cit., page 497.

⁴ Plate V, fig. 7.

the upper surface of the cœenchyma which separates them;¹ their margins are sharp, the fossa is shallow, and the columella rudimentary.

The septa are thin and well marked; they form six systems, and there are four cycles. The primary, secondary, and tertiary septa are very much alike, and extend well towards the centre of the calice. The septa of the fourth and fifth orders are short, and do not extend far from the wall.²

The columella is rudimentary, and consists of a few processes derived from the inner margins of the septa. It is made to appear larger than it really is, by the frequent development of the endotheca near the inner septal margins. In some calices it appears as if one of the larger septa crossed over the columellary space, and became connected to the opposite one.

The endotheca is greatly developed; the dissepiments incline so much that transverse sections of corallites or worn calices show numerous transverse bars between the septa:³ really these bars are but sections of oblique dissepiments.

The costæ, when covered by the exotheca, are rudimentary, and exist as faint unequal ridges which are slightly moniliform; but where they are above the cœenchyma, and close to the calicular margin, they are feebly developed, but distinct, unequal, alternately large and small, and bluntly dentate.⁴

The exotheca is abundant, and consists of small square cells, rectangular cells, and of a tissue in which the cells form a dense cœenchyma.⁵ It passes from corallite to corallite, and is marked on its upper or free surface by faint ovoid and rather flat elevations, which are close in some places but distant in others.⁶ The upper layer of the exotheca often grows up the sides of the corallites to the calices.

Height of corallum $\frac{6}{10}$ th inch. Diameter of corallites $\frac{2}{10}$ th inch (in the largest).

Locality.—Brockenhurst. In the Museum of Practical Geology, London.

2. SOLENASTRÆA KOENENI, *Duncan*. Pl. V, figs. 8, 9.

The corallum is short, gibbous, and irregular.

The corallites are rather but unequally distant from one another. The calices are hardly exsert, and are very shallow and open. There are no costæ visible, and a continuation of the cœenchyma upwards reaches the calicular margin.⁷

The septa are in six systems and there are four cycles. The septa are thin, delicate, wide apart, unequal, and occasionally not quite straight.⁸

¹ Plate V, fig. 1.

⁴ Plate V, figs. 5, 6.

⁷ Plate V, fig. 8.

² Plate V, figs. 3, 4.

⁵ Plate V, figs. 2, 5.

⁸ Plate V, fig. 9.

³ Plate V, fig. 3.

⁶ Plate V, fig. 7.

The columella hardly exists, and it is formed by a few offshoots from the inner margins of the septa.

The endotheca is scanty.

The wall is thin above, but thick low down in the corallites.

The exotheca is well developed; its cells are small, and its upper or free surface is but faintly marked.

Height of corallum $\frac{1}{2}$ inch. Diameter of corallites $\frac{2}{10}$ th inch.

Locality.—Brockenhurst. In the Museum of Practical Geology, London.

3. SOLENASTRÆA REUSSI, *Duncan*. Plate V, figs. 10—16.

The corallum is tall, with an irregular upper surface. The corallites are subturbinate, with wide calices and narrow bases; they are irregular in their distances, but are connected more by bands or layers of dense exotheca than by a cellular cœenchyma, but both structures exist.¹ The calices are very slightly exsert, and irregular in shape and distance. The fossa is shallow, and the margin is thin. The columella is very rudimentary. The septa are very distinct, unequal, not always straight, thin; and the highest orders are rudimentary, but exist as small projections. There are six systems and five cycles.² The laminæ are marked with granules in a series of slanting rows.³

The endotheca is very scanty and highly inclined.⁴

The wall is not very stout.

The costæ where uncovered by exotheca are distant, very slightly prominent, straight, unequal, and very bluntly dentate.

The exotheca forms layers which curve around the corallites, and connect them together at certain heights only, the intermediate parts being uncovered by exotheca; the uppermost layer is more or less granular, and reaches to the calicular margin.⁵ The layers are formed by elongated and very thick cells, and they rarely are square and thin. The gemmation is extra-calicular, but several buds spring from the same wall, very close to each other.⁶

Height of individual corallites $\frac{6}{10}$ th inch.

Diameter of the calices $\frac{3}{10}$ th inch.

Locality.—Brockenhurst. In the collection of Frederick Edwards, Esq., F.G.S.

¹ Plate V, figs. 10, 11, 14.

² Plate V, fig. 16.

³ Plate V, fig. 15.

⁴ Plate V, fig. 15.

⁵ Plate V, fig. 12.

⁶ Plate V, fig. 10.

4. *SOLENASTRÆA GEMMANS*, *Duncan*. Plate VI, figs. 1—7.

The corallum is tall, its base is small, and the calicular surface is very irregular.

The corallites are very unequal, they are sometimes crowded and for the most part are separated by cœenchyma; they are not very exsert, as a rule, but many pass up above the level of the common cœenchyma and exhibit their wall marked with small costæ.

The exotheca is dense, and resembles layers of membranous epitheca more than a cellular exotheca. It is found here and there only, so that much of the wall of many corallites is free. The exotheca spreads across from corallite to corallite in wavy horizontal layers, and the costæ are hidden by it. But where the exotheca is wanting the costæ vary greatly in their size and development.¹

The calices are irregular in shape, size, and distance; the fossa is shallow, and the columella is rudimentary. The calicular margin is rather blunt. The septa are long, delicate, very ragged on their sides, from their connection with the endotheca, and but slightly granular.² There are four cycles and six systems; the primary and secondary septa extend well inwards, and their ends, which are occasionally enlarged, are connected by ragged and irregular processes; the tertiary are smaller; and the septa of the fourth and fifth orders are almost rudimentary. Sections of corallites show the wall to be moderately thick.

The costæ are unequal, and are either plain, short and rounded, short and moniliform, short and bluntly dentate, or even almost vesicular. They are rudimentary when covered by the exotheca.

The endotheca is very abundant and highly inclined.³ The gemmation is peculiar, and causes the species to resemble in its growth some of the *Cladacoraceæ*: the bud separates widely from the parent, and then passes upwards and soon gives forth a bud which takes the same course.

Height of corallum several inches. Diameter of corallites $\frac{2}{10}$ th inch.

Locality.—Brockenhurst. In the collection of Frederick Edwards, Esq., F.G.S.

5. *SOLENASTRÆA BEYRICHI*, *Duncan*. Plate VI, figs. 8—13.

The corallum is massive, short, and has a very irregular calicular surface. The corallites are short, and widen out rapidly from a comparatively small base.

The calices are large, very irregular in shape, generally close, and they are separated by the cœenchymal exotheca; the fossa is shallow, the columella is rudimentary, the wall at the margin is stout, and the septa are thin, often wavy, and rugged laterally.

¹ Plate VI, figs. 2, 3, 4.

² Plate VI, fig. 7.

³ Plate VI, fig. 7.

There are six systems of septa, and four complete cycles; moreover, in the largest corallites there are many rudimentary septa of the fifth cycle. The septa are unequal in the sectional view; often larger (the primary) at the inner end than midway; and may extend across the columellary space. A little below the calice the wall is very thick, and the endotheca is most abundant and very inclined. The costæ exist above the level of the common cœnenchyma; they are alternately large and small, but always short, ill developed, and faintly dentate.

The exotheca is greatly developed; its cells are irregular in shape, not elongate, but more or less square in outline;¹ it covers up the corallites, leaving them free to a small extent only. The upper surface of this exothecal cœnenchyma is faintly granular.

Height of corallum 1 inch. Great diameter of calices $\frac{3}{10}$ th to $\frac{4}{10}$ th inch.

Locality.—Brockenhurst. In the collection of Frederick Edwards, Esq., F.G.S.

6. SOLENASTRÆA GRANULATA, *Duncan*. Plate VI, figs. 14—18.

The corallum is short, and its upper surface presents much granular cœnenchyma² between the calicular ends of the corallites. The corallites are small and distant; and in well-preserved specimens are seen to project somewhat above the common exothecal cœnenchyma, but in worn fossils they are but slightly elevated, and present a very thick wall. The calice is circular in outline, its fossa is shallow, its margin is thin; and the columella is rudimentary.

There are six systems of septa and four cycles of them; they are unequal, the primary being much the largest,³ and all except those of the fourth and fifth orders have a paliform elevation near the columellary space.

The septa are rugged laterally, from their connection with much endotheca, which is highly inclined.

The costæ are seen above the surface of the cœnenchyma as short ridges alternately large and small, and they appear to emerge into the large granules on the free surface of the cœnenchyma; where the corallites are not covered by exotheca below the free surface, the costæ are also visible.

The exotheca is cellular and banded.⁴ The occurrence of the bands admits of much corallite wall being costulated.

The free surface of the exotheca is dense and covered with large granules.

Height of corallum $\frac{1}{2}$ inch. Diameter of calices $\frac{2}{10}$ th inch.

Locality.—Brockenhurst and Roydon. In the collection of Frederick Edwards, Esq., F.G.S., and in the Museum of Practical Geology, London.

All these species present the most important generic characteristic of the *Solenastrææ*, and they are all very closely allied. The principal specific distinctions are in the amount

¹ Plate VI, fig. 9.

² Plate VI, fig. 14.

³ Plate VI, fig. 17.

⁴ Plate VI, figs. 15, 16.

and structure of the exotheca, in the method of gemmation, and in the septal development. These distinctions render the division of the Brockenhurst *Solenastrææ* into six species absolutely necessary. This increase in the number of the species proves that the genus must have been a large one; and the resemblance of the specific forms to varieties (from the really slight structural distinctions) is what is generally noticed in the case of large genera.

These new species belong to a division of the genus which is not represented elsewhere; it is characterised by the high septal number, the deficient columella, and the amount of inclined endotheca.

The recent *Solenastrææ* are found in the Red Sea, the Caribbean Sea, and in the Indian and Pacific Oceans. The horizontal endotheca and low septal number distinguish all these species from those of Brockenhurst.

The fossil species of the genus are *Solenastræa Verhelsti*, Ed. and H., *Solenastræa Turonensis*, Michelin sp., and *Solenastræa composita*, Reuss sp.

Solenastræa Verhelsti is an Eocene form from Ghent; and its rudimentary third cycle of septa, very close corallites, and its paucity of slightly oblique and subconvex endotheca, distinguish it at once and very decidedly.

Solenastræa Turonensis has very long and close corallites with three cycles of septa and a well-developed columella; its very scanty and very feebly inclined endotheca, and the wide-apart exothecal dissepiments, separate it from the form from Ghent, as well as from those from Brockenhurst. MM. Milne-Edwards and J. Haime determine that this species and *Solenastræa composita* are identical. The Touraine form is of course from the Upper Miocene.

The following is a scheme of the classification of the Tertiary *Solenastrææ*:

<i>Solenastrææ</i> , with the columella	Rudimentary.	The septa in four cycles.	The endotheca greatly developed.	Exotheca very cellular and complete	<i>Cellulosa.</i>
				Exotheca, banded and cellular, incomplete.	{ Gemmation frequent . . . } <i>Gemmans.</i>
			The endotheca not much developed.		{ Calices small; septa with paliform lobe } <i>Granulata.</i>
				Exotheca cellular and complete . . .		Koeneni.
			Five cycles complete, or nearly so.	Corallites partly covered with cellular and banded exotheca	} <i>Reussi.</i>
				Corallites completely covered with cellular exotheca	} <i>Beyrichi.</i>
			Three cycles	<i>Verhelsti.</i>	
			well developed. Three cycles of septa; corallites close; endotheca slightly developed	} <i>Turonensis.</i>	

SECTION—*MADREPORARIA PERFORATA*.FAMILY—*Madreporidæ*.

SUB-FAMILY—EUPSAMMINÆ.

Genus—BALANOPHYLLIA.

BALANOPHYLLIA GRANULATA, *Duncan*. Plate VII, figs. 1—5.

The corallum is short, has a very large and encrusting base, and is constricted immediately below the calice. There is no epitheca, and the costæ are large and very distinct.¹

The calice is oval in outline, is compressed, and is marked by very small and equal costæ externally; it has a small columella and very numerous septa.

The septa are delicate, wavy, and granular; there are six systems of them and five complete cycles, with half of a sixth.

Very large, equal, rather wavy, flat, and rounded costæ are seen at the edge of the base; they bifurcate inferiorly² here and there, and are profusely granular, as well as connected by many cross bars.

As the costæ approach the constriction they diminish in size, become thinner, more numerous, and less granular, until, close to the calicular margin, they are almost linear. All are connected by the cross bars. The granules often are large enough to stand up well in relief.

Height of corallum $\frac{1}{4}$ inch. Diameter of base $\frac{1}{3}$ rd inch. Diameter (greatest) of calice $\frac{6}{10}$ th inch.

Locality.—Brockenhurst. In the collection of Frederick Edwards, Esq., F.G.S.

The genus *Balanophyllia* (Wood) has received much attention since MM. Edwards and Haime's 'Monograph on the British Fossil Corals' was written. These authors have described in the 'Histoire Naturelle des Coralliaires' (vol. 3) some new species.

Since that work was completed Reuss has described three species from the "lower marine sand" of Weinheim: and F. Roemer and Philippi have each discovered a new species in the fossiliferous beds of Latdorf. Moreover, the South Australian Tertiary beds contain species.

The *Balanophyllia calyculus*, Wood; *B. verrucaria*, Pallas, sp.; *B. cylindrica*, Michelotti, sp.; *B. Italica*, Michelin, sp.; *B. tenuistriata*, Ed. and H.; *B. desmophyllum*, Lons-

¹ Plate VII, figs. 1, 2.

² Plate VII, figs. 2, 3.

dale sp.; *B. Bairdiana*, Ed. and H.; *B. geniculata*, D'Archiac; *B. Cumingii*, Ed. and H., and *B. subcylindrica*, Philippi sp., may be arranged together to form a subgenus characterised by forms with broad adherent bases. The following species will fall into another subgenus whose forms have the base more or less pedicillate:—*Balanophyllia prælonga*, Michelotti, sp.; *B. Gravesii*, Michelin, sp.; *B. sinuata*, Reuss; *B. inæquidens*, Reuss; *B. fascicularis*, Reuss, and *B. Australiensis*, Duncan.

The new species from Brockenhurst, *B. granulata*, must be received into the first subgenus. The absence of epitheca, the profusely granular costæ, and the existence of part of the sixth cycle of septa, distinguish *B. granulata* from all the species already described.

There is nothing in the species *B. granulata* to connect it with any geological horizon; for the *Balanophylliæ* without epitheca range from the Eocene to the present day. The species *B. granulata* has only a generic alliance with those described by Reuss, Roemer, and Philippi.

Genus—LOBOPSAMMIA.

LOBOPSAMMIA CARIOSA, Goldfuss, sp. Plate VII, figs. 6—10.

The corallum has a wide base, above which it is slightly constricted. It rises in the form of a short cylindrical trunk, terminated by several gibbous processes, which support calices and project outwards.

The under surface of the base has a concavity¹ which is lined and surrounded for a short distance by a dense epitheca; the costæ radiate around the margin of the epitheca, and ascend the outside surface of the corallum, pursuing very irregular and wavy courses, being thin, rounded, equal, and joined laterally by numerous cross bars of exotheca.

The costæ, which are very faintly granular, have this same peculiarity² on the upper surface of the corallum between the gibbous calices.

The calices are irregular in shape, and so speedily commence to elongate prior to dividing fissiparously, that simple ones are rarely seen. They are, nevertheless, in the figure of eight, and are situated on the ends of the gibbous projections; their margins are irregular, the fossa is shallow, and the columella is very feebly developed.

The septa are very numerous, and form at least five cycles in six systems; they are unequal, stout, and often bifurcate near the columella.

Height of corallum about one inch; diameter of trunk $\frac{9}{10}$ ths inch; greatest diameter of calices $\frac{4}{10}$ ths inch.

Locality. Brockenhurst, Acy, Auvert, and Valmondois.

¹ Plate VII, fig. 10.

² Plate VII, fig. 7.

In the Museum of Practical Geology, London, and in the collection of Frederick Edwards, Esq., F.G.S.

Lobopsammia cariosa is a common fossil at Brockenhurst, and the specimens differ in the stoutness of the corallum and distinctness of the costæ. There is a so-called species, *L. dilatata*, Roemer,¹ from Latdorf;² but it is not worthy of more than the title of a variety of our widely diffused form. The same may be determined with respect to *L. Parisiensis*, Michelin, sp.

SECTION—*MADREPORARIA PERFORATA*.

FAMILY—PORITIDES.

Sub-family—PORITINÆ.

Genus—LITHARÆA.

LITHARÆA BROCKENHURSTI, *Duncan*. Plate VII, figs. 17, 18.

The corallum is massive, irregular in shape, and has an uneven upper surface. The corallites are close, and are very rarely separated by much reticulate cellular structure; they are rather short, and vary in their diameter in different parts of the corallum. The walls are well marked.

The calices are shallow, close, and generally quadrangular. The margins are formed by trabecular tissue, and the septa are irregular, unequal, wavy, and are often enlarged at the inner end; their laminæ are much perforated; they are in six systems, and there are three cycles, the primary being the largest; the others are often very small. The laminæ are faintly dentate laterally.

The columella is slightly developed, and appears to be formed by processes from the septal ends. Diameter of the calices $\frac{4}{30}$ ths inch.

Locality. Brockenhurst. In the collection of Frederick Edwards, Esq., F.G.S.

The scanty cœnenchyma, the shallow and quadrangular calices, the three cycles of unusually perforate septa, the ill-developed columella, and the shape of the corallum, distinguish this species from *Litharæa Websteri* and the *Litharææ* of the French Tertiaries.

The genus ranges from the Maestricht Chalk to the Faluns at Dax.

¹ Roemer in Dunker's 'Palæontographica,' 1862—1864.

² In the Lower Oligocene.

SECTION—*MADREPORARIA TABULATA*.

FAMILY—MILLEPORIDÆ.

Genus—*AXOPORA*.

AXOPORA MICHELINI, *Duncan*. Plate VII, Figs. 11—15.

The corallum is large, very irregular in shape, and marked by inequalities of the surface. The cœenchyma is abundant, very finely reticulate, and is dotted by numerous and very small calices, which are not very deep, and often irregular in shape; they are not separated by ridges. The columella is formed by longitudinal fibres, and projects but slightly at the bottom of the calice; it is slender, very long, and often wavy.

There are no septa.

The tabulæ are horizontal, not numerous, very small, and do not go through the columella, and divide the corallite off perfectly.

A variety of this species is in the form of a flat cake, and its corallites are very long and thin.¹

Locality. Brockenhurst. In the collection of Frederick Edwards, Esq., F.G.S.

Axopora is a very remarkable genus, for its corallites have no septa, but a great columella and tabulæ. The tabulæ do not pass through the fasciculate columella, and yet they cut off all the space below them from that nearer the calice.

The species are not numerous; they were probably rapid growers, and the structures entering into their composition are so simple that it is very difficult to determine specific distinctions.

The *Holoræa Parisiensis*, which is synonymous with *Alveolites Parisiensis*, Michelin, and which was described by MM. Milne-Edwards and Jules Haine, in the first part of their Monograph, has been determined by them to be an *Axopora*. The *Axopora Michelini* is a very large and fine form, and is closely allied to *Axopora Solanderi*, DeFrance, sp., and less so to *A. Fisheri*, Dunc., but it differs very decidedly from *A. Parisiensis*.

¹ Plate VII, figs. 13, 15.

SECTION—*MADREPORARIA PERFORATA*.

FAMILY—MADREPORIDÆ.

Genus—MADREPORÆ.1. *MADREPORÆ SOLANDERI*, *Defrance*. Plate VIII, figs. 12—14.

The corallum is arborescent; the branches are subcylindrical.

The calices are sunken in the very porous cœnenchyma, and they are large and wide apart.

This is the description given by MM. Milne-Edwards and J. Haime,¹ and the following is from Michelin:²

M. ramosa, porosa; ramis subcylindricis, sæpe compressis, raro coalescentibus, granulosis; stellis universis, rotundis; lamellis 12 fragilissimis, 6 maximis, aliis parvulis.

The Brockenhurst specimen shows the granulated cœnenchyma and the septa; but it proves that the calices, like all others of the genus, were more or less prominent before being worn.

Localities. Brockenhurst. Mary près Meaux (Seine et Marne), Auvert, Graux, and Valmondois. In the collection of Frederick Edwards, Esq., F.G.S.

2. *MADREPORÆ ROEMERI*, *Duncan*. Plate VIII, figs. 8—11.

The corallum is partly foliaceous and partly ramose, but the branches coalesce.

The calices are very distant and, in unworn portions of the corallum, are on the top of conical and very costulated projections. The calicular margin and the conical base produce a "tubuliform calice."

The costæ are projecting, wavy, rounded, and are lost in a very granular and almost echinulate cœnenchyma.

The septa are stout, and twelve in number.

Locality. Brockenhurst. In the Museum of Practical Geology, London.

3. *MADREPORÆ ANGLICA*, *Duncan*. Pl. VIII, figs. 1—7.

The corallum is in the shape of a stout trunk, with numerous aborted branches which give it a very gibbous appearance.

¹ Op. cit., vol. iii, p. 162.

² 'Icon. Zooph.,' p. 165.

The calices are either scattered irregularly over the papillate cœnenchyma or are aggregated in sets; a parent corallite being surrounded by its buds. The calices are small but slightly projecting, tubuliform and finely costulated, the costæ being lost in the irregular, porose, and papillate common tissue. Some are not costulated, but are sunken in the cœnenchyma, and all are circular in outline with thickish walls.

The septa are as is usual in the genus; and the opposite primary septa frequently join by their inner ends. There are six large and six small septa.

The cœnenchyma is highly cellular, and its free surface is almost aciculate with sharp papillæ. *Locality.* Brockenhurst. In the Museum of Practical Geology, London.

These species of the genus *Madrepora* are all new to the British coral-fauna. *M. Solanderi* is an indifferent species, for there may have been any amount of ornamentation on the cœnenchyma, and the calices may have been very prominent and costulate, but nearly every detail has been worn off the specimens. Many well-characterised species, were they worn and rolled, would present the appearance of the typical specimen of *M. Solanderi*.

Madrepora Roemeri is well characterised by its form, its distant tubuliform calices with costulated external surfaces, and by its very granular and echinulate cœnenchyma. The species most closely allied to *M. Roemeri* is *M. granulosa*, Edwards and Haime, a recent form from the Ile de Bourbon.

The *Madrepora Anglica* is a well-marked species, and is allied to *M. crassa*, Edwards and Haime, a recent form whose locality is unknown.

The genus *Madrepora* comprehends at least ninety-two species, of which only eight are fossil. The Paris Basin and the Turin Miocene have hitherto been the localities whence the fossil species have been collected; and now the Brockenhurst beds must be admitted amongst the strata whose remains indicate the former existence of coral-reefs exposed to a furious surf and the wash of a great ocean.

The Brockenhurst *Madrepore* do not resemble, except generically, the species from Turin.

The recent species are found all over the Pacific, the Indian Ocean, the Caribbean Sea, and one species has retained its position in the White Sea, near Archangel (*M. borealis*, Edwards and Haime).

As yet the very fossiliferous Tertiary strata of the islands of the West Indies have not yielded any fossil *Madrepora*.

REMARKS ON THE CORAL-FAUNA OF BROCKENHURST.

The coral-fauna of Brockenhurst and Roydon consists of thirteen species:—*Solenastrea cellulosa*, *S. Koeneni*, *S. Reussi*, *S. gemmans*, *S. Beyrichi*, *S. granulata*, *Balanophyllia granulata*, *Lobopsammia cariosa*, *Axopora Michelini*, *Litharæa Brockenhursti*, *Madrepora Anglica*, *M. Roemeri*, *M. Solanderi*.

Two of the species, viz., *Lobopsammia cariosa*, Goldf., sp., and *Madrepora Solanderi*, Defrance, sp., are found in the Eocene beds of the Paris Basin; they have not, however, been noticed either in the London Clay or in the Bracklesham and Barton beds in England.

The *Madrepora Solanderi* is a species of very doubtful value, and the reasons for this assertion have been already given.

The *Lobopsammia cariosa* is found under the name of *L. dilatata*, Roemer, at Latdorf.

The *Litharæa* and the *Axopora* from Brockenhurst have no very close specific alliance with the forms of the genus found in the London Clay and the Bracklesham beds.

The Nummulitic coral-fauna¹ of Italy, Sinde, &c., has no species in common with that of Brockenhurst; and the researches of Reuss and Roemer in the coral-faunæ of the Tertiary series termed Lower, Middle, and Upper Oligocene, have not produced any results which enable me to correlate any one of those series with the coraliferous beds at Brockenhurst.

The Miocene coral-fauna has no specific relationship with that under consideration.

It becomes evident from these considerations that the new coral-fauna has very slight resemblances and affinities with those already described.

The Brockenhurst corals are, therefore, very remarkable; the absence of simple forms and the presence of species of *Madrepora*, *Axopora*,² and *Solenastræa* indicate the former existence of a vigorous polype-growth, and of all the physical conditions now observed near and about coral-reefs. The great size of the trunk of *Madrepora Anglica* is especially significant. It may be still true that this coral-fauna was a local one, for at the present day the distinction between reef-, barrier-, and simple coast-corals is sufficiently determinable.

The coral-fauna of the so-called Lower Oligocene beds of Germany is associated with the mollusca which characterise the Brockenhurst beds and their equivalents in the Headon series of the Isle of Wight.³ It is distinct from the coral-fauna of Brockenhurst, although the correlation of the strata can be established from the study of the Mollusca; hence the probabilities of the Latdorf coral-fauna being that of a coast-line, and of the Brockenhurst being that of an oceanic and reef area, are great.

The coral-fauna of Brockenhurst is more recent than that of Barton and evidently flourished under very different physical conditions. It is older than the Falunian and Crag-faunæ.

¹ The coral-fauna of the London Clay, and of the Bracklesham and Barton beds, and of the Paris Basin, is contained to a certain extent in the great Nummulitic coral-fauna of Southern Europe and India; but there were clearly two coral-provinces during the early Tertiary period, just as there are at the present day—the West Indian and the Pacific.

² *Axopora* is represented in existing reefs by many tabulate corals.

³ Von Koenen, "Die Fauna der Unter-Oligocänen Tertiär-Schichten von Helmstädt," 'Zeitschrift der Deut. geol. Gesell.,' Band xvii, 1865.

VIII. CORALS FROM THE EOCENE OF THE ISLE OF WIGHT AND FROM THE LONDON CLAY.

ORDER—*ZOANTHARIA*.FAMILY—*TURBINOLIDÆ*.Tribe—*TURBINOLINÆ*.Genus—*TURBINOLIA*.1. *TURBINOLIA AFFINIS*, *Duncan*. Plate IX, figs. 1, 2, 3.

The corallum is slightly truncated inferiorly, and it is conical low down, but cylindro-conical above; it is symmetrical and very small.

The costæ are well developed and obtuse; the largest are swollen out inferiorly, and all are moderately prominent; not very thick, but very distinct.

The intercostal spaces are wide on account of the costæ being separated by a portion of the wall, which is very visible at the bottom of the spaces.

There are no dimpled markings on this portion of the wall.

There are very decided markings on the sides of the costæ produced by rudimentary exotheca.

The wall is thin.

The calice is circular in outline.

The septa are thin, delicate, unequal, rather ragged, granular, and slightly enlarged near the columella. There are three perfect cycles of septa and six systems.

The numbers of the septa and costæ are the same.

The columella is not very projecting above the base of the calicular fossa, and is rather elongated and ovoid.

The height of the corallum is $\frac{2}{10}$ ths inch, and the diameter of the calice nearly $\frac{1}{10}$ th inch.

This species is more closely allied to the rare *Turbinolia firma*, Edwards and Haime, than to any of the other members of the genus. The broad intercostal spaces and the markings on the sides of the costæ in the new species distinguish it from *Turbinolia firma*.

Locality. High Cliff, Isle of Wight. In the collection of Frederick Edwards, Esq., F.G.S.

2. *TURBINOLIA EXARATA*, *Duncan*. Plate IX, figs. 4, 5, 6, 7.

The corallum is conical inferiorly and cylindrical superiorly, so as to be rather sub-turbinate. Its base is small and narrow, although the costæ are very projecting there.

The costæ are greatly developed; they are subequal, very prominent, and thin; their free margin is rather sharp, and not much narrower than their base.

The largest costæ are very prominent inferiorly, and the tertiary arise at the distance of about one quarter of the whole height of the corallum from the base.

The costæ are very wide apart, and the base or bottom of the intercostal spaces is wide, very visible, and it is not marked by any dimpling.

The sides of the costæ are strongly marked with a rudimentary exotheca, which is attached to the wall close to the base of the costæ (fig. 7).

The wall is very thin.

The calice is circular in outline, very deep, and its margin is rendered very distinct by the well-developed costæ.

The septa are slender, thin, and unequal; they form three perfect cycles, and there are six systems.

The septa and costæ correspond.

The columella is very small, cylindrical, pointed, and in the typical specimen there are two papillæ on its free surface.

Height $\frac{4}{10}$ ths inch. Diameter of the calice $\frac{3}{10}$ ths inch.

This very interesting species resembles the *Turbinolia Prestwichi*, Edwards and Haime, in some points; but it has no vestige of a fourth cycle of costæ; moreover, the new species has not the truncated base of *Turbinolia Prestwichi*, and its third cycle of costæ arise high up.

The width of the intercostal furrows and the absence of well-marked dimpling are very distinctive peculiarities of *Turbinolia exarata*.

Locality.—The species is found at Brook, Hampshire (New Forest). In the collection of Frederick Edwards, Esq., F.G.S.

3. *TURBINOLIA FORBESI*, *Duncan*. Plate IX, figs. 8, 9, 10, 11.

The corallum is very small, conico-cylindrical, and has rather a sharp base.

The costæ are very stout, obtuse, and slightly prominent; the largest are often wavy in their upward course, and all are separated by wide intercostal furrows or spaces. There is a well-marked but very small costa situated high up in the corallum and in each intercostal space.

There are large and distinct exothecal markings on the sides of the costæ; but the existence of dimples on the wall at the bottom of the intercostal spaces is too doubtful to be safely asserted.

The calice is unsymmetrical, from its peculiar septal arrangement; its marginal wall is very thin, and the fossa is deep. The columella is angular in its transverse outline, and is often very prominent.

The septa are unequal, straight, and delicate. There are no septa corresponding with the rudimentary costæ; their arrangement gives the idea of there being two systems of three cycles, the septa of the third cycle being deficient; but there are really six systems.

In four systems there are three cycles of septa, and the rudimentary costæ are of the fourth and fifth orders; and in the remaining systems there are two cycles of septa with the rudimentary costæ of the third order.

Height of corallum $\frac{3}{40}$ ths inch. Diameter of the calice $\frac{1}{40}$ th inch.

The cyclical arrangement and the rudimentary costæ distinguish this species from all the others.

Locality. High Cliff, Isle of Wight. In the collection of Frederick Edwards, Esq., F.G.S.

The genus *Turbinolia*, thus enriched by the discovery of three new species, was so elaborately described by MM. Milne-Edwards and J. Haime, that it only remains to place these species in their proper position in the genus.

The following scheme will point out their correct affinities:

TURBINOLIÆ.			
TURBINOLIÆ with four cycles of septa; the fourth more or less incomplete.			
,,	,,	,,	<i>Turbinolia costata.</i> 1.
			— <i>dispar.</i> 2.
			— * <i>exarata</i> . ¹ 3.
			— * <i>Dixoni.</i> 4.
			— * <i>firma.</i> 5.
			— * <i>affinis.</i> 6.
,,	three cycles of septa	}	— <i>Pharetra.</i> 7.
			— <i>laminifera.</i> 8.
			— <i>Nystana.</i> 9.
			— <i>attenuata.</i> 10.
			— <i>pygmæa.</i> 11.
,,	three cycles of septa, with costæ of a fourth cycle	}	— * <i>sulcata.</i> 12.
			— * <i>Bowerbanki.</i> 13.
			— * <i>Fredericiana.</i> 14.
			— * <i>Prestwichi.</i> 15.
,,	three incomplete cycles of septa	}	— * <i>minor.</i> 16.
			— * <i>Forbesi.</i> 17.
			— * <i>humilis.</i> 18.

¹ The species marked with an asterisk are British.

Turbinolia attenuata, Keferst. { These species require further examination; they were discovered
— *laminifera*, Keferst. { in the "Unter-Oligocæn" of Germany, are very minute forms,
— *pygmæa*, Roemer. { and are probably the young of other species.

FAMILY—*CARYOPHYLLIACEÆ*.Tribe—*TROCHOCYATHACEÆ*.Genus—*TROCHOCYATHUS*.1. *TROCHOCYATHUS AUSTENI*, *Duncan*. Pl. IX, figs. 15—17.

The corallum is rather tall, slightly curved and compressed; it is rounded at the base, and its sides are marked with slightly prominent but not spined or crested costæ.

The calice is elliptical, much compressed, and slightly angular at its extremities; its long axis is on a lower plane than the short axis, and its margins are raised into several angular processes, on account of the primary and secondary septa being less exsert than the tertiary.

The fossa is moderately deep; and the columella is long, and not very visible. The septa are thin, rather close, and very subspinose laterally.

The septa are in six systems, and there are four perfect cycles. The septa are unequal, and are not very exsert: the primary and secondary septa are on a lower level than the others, and correspond to the largest and most prominent costæ.

There are small pali before the primary, secondary, and tertiary septa.

The costæ are distinct from the base, and granular; the primary and secondary are the largest, and all are broader than the septa. Height of corallum, $\frac{9}{10}$ ths inch. Great diameter of calice, $\frac{5}{10}$ ths inch. Small diameter of calice, $\frac{3}{10}$ ths inch.

This species belongs to the striated *Trochocyathi*;¹ and its tall and curved form, with its four cycles of septa, bring it in close relation with *Trochocyathus elongatus*, Edwards and Haime.² The angular calicular margin is wanting in this last species, whose corallum is moreover slightly twisted.

It is very evident that the new species is the representative of *Trochocyathus elongatus*. *Trochocyathus elongatus* is found at Quartier-du-Vit, near Castellane (Basses Alpes), in an Eocene formation, and *Trochocyathus Austeni* was discovered at Bracklesham.

In the collection of Frederick Edwards, Esq., F.G.S.

2. *TROCHOCYATHUS INSIGNIS*, *Duncan*. Pl. X, figs. 1—4.

The corallum is tall, compressed, slightly curved inferiorly, and it has a large calice and a sharp base.

The calice is ovoid, and its axes are on the same plane.

¹ 'Hist. Nat. des Corall.,' vol. ii, p. 27.

² 'Ann. des Sc. Nat.,' 3rd ser., vol. ix, p. 305, 1848.

The septa are small, thin, wavy, unequal, and have very long and sharp lateral spines. The septa are in six systems, but the four cycles are incomplete. The four cycles are complete in two systems, but are incomplete in one of the halves of each of the other systems. There are therefore eight septa in two systems and six in the rest.

The columella is small and situated deeply.

The pali are small, and are situated before all the septa, except those of the last cycle.

The costæ are subequal, broad, very slightly rounded, and barely prominent; they are generally marked by three rows of granules, and at the calicular margin they become conical, and ornamented with a prominent and wavy ridge-like process, which passes downwards, becoming soon lost in a faint fissure, which may be seen on most of the costæ low down.

Height, $\frac{9}{10}$ ths inch. Great diameter of calice, $\frac{1}{2}$ inch. Small diameter of calice, between $\frac{3}{10}$ ths and $\frac{4}{10}$ ths inch.

This species is readily distinguished from all other striated *Trochocyathi* by its shape, septal arrangement, small pali, and the curious ornamentation of the costæ.

Locality. Whetstone (London Clay).

In the collection of N. T. Wetherell, Esq., F.G.S.

These are the only *Trochocyathi* which are known in the London Clay, and it is very doubtful if *Trochocyathus sinuosus*, Brongniart, sp., was ever found there.¹

Genus—PARACYATHUS.

1. PARACYATHUS CYLINDRICUS, *Duncan*. Plate IX, figs. 18—21.

The corallum is cylindrical, straight, tall, and has a flat base, whose diameter is nearly equal to that of the corallum. There is a constriction just above the base, the wall is often marked with growth-rings, and in some corallites the calice is slightly expanded.

The calice is circular in outline, its fossa is shallow, and the columella very small.

The septa are slightly exsert, and in some calices more so than in others; they are delicate, are marked with large granules laterally (fig. 21), and have an irregular upper margin.

There are six systems of septa, and three perfect cycles; moreover, in one half of four or more systems a septum of the fourth cycle is developed. The septal number is therefore very irregular, and there are from twenty-eight to thirty septa in the calice. The

¹ See 'Corals of the London Clay,' MM. Edwards and J. Haime, page 22.

pali are small and lobular, and appear to be placed before all the septa except those of the fourth cycle.

The costæ are distinct from the base upwards, are subequal, slightly prominent, and granular. The intercostal grooves are very distinct. Near the calicular margin the costæ are often found projecting outwards and becoming exsert.

Height of the corallum $\frac{1}{4}$ — $\frac{1}{2}$ inch. Diameter of the calice $\frac{3}{10}$ ths inch.

Locality, Bramshaw, New Forest. In the collection of Frederick Edwards, Esq., F.G.S.

2. *PARACYATHUS HAIMEI*, *Duncan*. Plate IX, figs. 12—14.

The corallum is short and broad, and its base is nearly as broad as the calice.

The wall is thin.

The calice is irregularly elliptical, and its long axis is on a lower plane than the short axis. The margin is sharp and irregular, the fossa is not deep, and the columella does not occupy very much space.

The septa are slender, crowded, unequal, granular, and slightly exsert. There are six systems, and the arrangement of the cycles is very irregular. There are two systems in which the septa of five cycles are complete, two in which they are incomplete, and two presenting septa of four cycles only. The primary septa are readily distinguished, and all the septa are long and often flexuous. The tertiary septa join the secondary in some systems.

The pali are present before all the septa, except those of the last cycle.

The columella is spongy.

The costæ are thin, sharp, laminate, and project; they are often slightly flexuous, and their free margin is moniliform. The intercostal spaces are wide and deep.

There are traces both of exotheca and of endotheca.

Height of corallum $\frac{2}{10}$ ths inch. Great diameter of calice $\frac{2}{10}$ ths inch.

Locality, Barton. In the collection of Frederick Edwards, Esq., F.G.S.

These *Paracyathi* are closely allied to the species already described from the London Clay, by MM. Milne-Edwards and J. Haime.

P. Haime differs, however from its nearest ally, *P. crassus*, in its septal arrangement, in the sharpness and ornamentation of the costæ, and in the size of the intercostal spaces.

P. cylindricus has some resemblance to some varieties of *P. caryophyllus*, but the septal arrangement, the small columella, and the very small pali, distinguish it.

FAMILY.—OCULINIDÆ.

Tribe.—OCULINACEÆ.

Genus.—OCULINA.

1. OCULINA INCRUSTANS, *Duncan*. Plate IX, figs. 22—24.

The corallum is small and encrusting. There is much cœenchyma, but it is not granular on the surface; it is marked near the calices by very faint costal ridges.

The calices are arranged without order, and are situated upon more or less prominent eminences; they are usually circular in outline, but there are indications of fissiparity. The calicular margin is sharp, the fossa is shallow from the presence of a large and prominent columella, and the spaces bounded by the columella, the margin, and the primary septa are deep.

The primary and secondary septa are long and nearly equal; they reach the columella and appear to be extended over its upper surface, but this appearance is really produced by the pali.

There are four cycles of septa, and six systems; but the septa of the fourth and fifth orders are very small. All the septa are delicate, rather narrow, and very unequal, except in the case of the primary and secondary.

The pali are before all the septa, except those of the last cycle; they are small and indistinct.

The columella is bulky, projected, rounded, and probably was papillated.

The costæ are very faintly marked, are not straight, and can hardly be said to exist.

Height of calicular projections $\frac{3}{10}$ ths inch. Diameter of calice $\frac{2}{10}$ ths inch.

Locality. Bracklesham. In the Sharpe Collection of the Geological Society.

The deficiency of granular cœenchyma, the existence of additional septa, the bulky columella and the thin pali, distinguish this species from *O. conferta*.

2. OCULINA WETHERELLI, *Duncan*. Plate X, figs. 5—7.

The corallum is short, has a very broad base for its size, is constricted above the base, and expands into a calice. It increases by gemmation just below the calicular margin; many buds are aborted.

The surface is very finely granular under high magnifying powers, but smooth to the naked eye.

The calice is nearly circular in outline, and has a moderately thick wall and a deep fossa.

Its septa are delicate, unequal, thin, and belong to four cycles, there being six systems. The primary are the longest, and there are small pali before all except the septa of the fourth and fifth orders.

The columella is small, blunt, and delicately papillose.

There are no costæ.

Height of corallum $\frac{1}{10}$ th— $\frac{2}{10}$ ths inch. Diameter of calice $\frac{1}{10}$ th— $\frac{2}{10}$ ths inch.

Locality. Ballard's Lane, Finchley (London Clay). In the collection of N. T. Wetherell, Esq., F.G.S.

This species is closely allied to *O. conferta* and *O. incrustans*, and but remotely to *O. Halensis*.¹ The gemmation, the small columella and pali, and the septal arrangement, distinguish the new species.

SECTION—*MADREPORARIA PERFORATA*.

FAMILY—MADREPORIDÆ.

Sub-family—EUPSAMMINÆ.

Genus—DENDROPHYLLIA.

DENDROPHYLLIA ELEGANS, *Duncan*. Plate X, figs. 15—19.

The corallum has a broad encrusting base which gradually tapers into a tall, slender, and straight stem, terminated by a calice. Gemmation occurs close below the calicular margin on the outside wall, and the branches are in whorls, are long, and do not coalesce.

The calices are either circular in outline or compressed; they are deep, have a very irregular cellular margin, and a very regular septal arrangement; they vary in size, and are peculiarised by long, thin, and delicate septa, and large interseptal loculi.

There are six systems of septa, and four complete cycles; all the septa are well developed, laminar, and project very decidedly from the wall. The primary and secondary are straight and project well inwards; and processes from them develop the columella. The tertiary septa are small, but well produced; and the septa of the fourth and fifth orders meet externally to the tertiary septa and proceed to the columella. The laminae are sharply granular, but not irregularly so, and their perforations are decided.

The columella is formed by processes from the ends of the septa, and is small.

The costæ are close, rounded above, and wider and more flattened below. The upper

¹ Fossil Corals from Sinde: 'Ann. and Mag. Nat. Hist.,' April, 1864.

costæ are granular either in series of one or of two rows, whilst the lower present many irregular rows. The cross bars of the exotheca are numerous.

Height of corallum 2 inches. Diameter of calice $\frac{3}{10}$ ths inch.

Locality.—Bracklesham. In the Dixon Collection in the British Museum.

This species, very closely allied to *D. dendrophylloides*, is distinguished from it by the habit of growth, by there being multi-granulose costæ, and by the development of the higher orders of the septa.

SECTION—*MADREPORARIA PERFORATA*.

FAMILY—MADREPORIDÆ.

Sub-family—TURBINARINÆ.

Genus—DENDRACIS.

Dendracis—generic characters.¹

Corallum arborescent; cœnenchyma very dense, granulated on the surface; calices submammiiform; no columella; septa few in number and barely exsert.

DENDRACIS LONSDALEI, *Duncan*. Plate X, figs. 11—14.

The corallum consists of stems branching laterally, both the stems and branches being nearly cylindrical.

The cœnenchyma is very abundant, is covered with blunt conical dentations, and the calices are rare, but slightly elevated, and very small. The calices seem to be defects in the cœnenchyma rather than independent structures. They are wide apart, circular, shallow, and have no columella. The septa are twelve in number, very large at the margin, and every other one has a thin continuation which passes inwards. The central space is deep. There are no costæ (fig. 12).

The transverse section of a stem shows its cellular nature, and that it consists of superimposed cœnenchymal cells (fig. 13).

Diameter of stems $\frac{2}{10}$ ths inch. Diameter of calices $\frac{1}{40}$ th inch.

Locality. Bracklesham. In the Dixon Collection in the British Museum.

The wide apart and rare calices, and the strongly echino-dentate cœnenchyma, distinguish this species from the *Dendracis Gervillii*, DeFrance, sp.

The new species is attached to the under part of the base of Lonsdale's typical specimen of *Porites panicea* described in Dixon's 'Geology of Sussex' (pl. i, fig. 7).

¹ 'Hist. Nat. des Corall.,' vol. iii, p. 169.

SECTION—*MADREPORARIA PERFORATA*.

FAMILY—PORITIDÆ.

Sub-family—PORITINÆ.*Genus*—PORITES.

PORITES PANICEA, *Lonsdale*.¹ Plate X, figs. 8—10.

The corallum is flat and encrusting, and its upper surface is irregular.

The calices are small, circular, and either crowded or rather distant. In the first instance, the outer margins of the septa are in close contact, and in the second there is more or less granular cœnenchyma between the calices.

The calices vary in the depth of their fossæ, but the septa are always thick externally and thin internally; they are granular superiorly and laterally. There are six large and six small septa; the largest are connected by pali with a solid columella. All are rather exsert.

The longitudinal section shows the corallites to be deep, to have some endotheca, to be very porose, and to be united by a cœnenchyma of very distinct cells. The amount of this cœnenchyma varies according to the approximation of the corallites.

Height of corallum $\frac{3}{4}$ ths inch. Diameter of calices $\frac{1}{10}$ th inch.

Locality. Bracklesham. In the Dixon Collection in the British Museum.

There can be no doubt about this coral possessing a granular cœnenchyma, a columella, and pali. It is not the *Astræa panacea* of Michelin,² which is really an *Astræopora*,³ having neither columella nor pali. The *Porites panicea* has more lamellate septa and a more decided cœnenchyma than the other species of the genus, and it unites the genera *Astræopora*, *Porites*, and *Litharæa*. The species has no resemblance to the *Porites incrustans*, DeFrance, from the Miocene of Turin, nor has it close alliances with any of the recent forms.

¹ 'Dixon, 'Geol. and Foss. of Sussex,' pl. i, fig. 7.

² Michelin 'Iconogr.,' pl. 44, fig. 11.

³ Pictet, 'Paléont.,' vol. iv.

SECTION—*MADREPORARIA TABULATA*.

FAMILY—MILLEPORIDA.

Genus—AXOPORA.

AXOPORA FISHERI, *Duncan*. Plate X, figs. 20—22.

The corallum is large ; it has an oval encrusting base, and a gibbous and tumid upper surface and sides.

The cœnenchyma is coarsely reticulate even for an *Axopora*, and is very abundant.

The calices are larger than usual in the genus, are very distinct, rather distant, and are separated by irregular elevations of the cœnenchyma.

The columella is large, is very simple and prominent, and is rounded and rather sharp. The tabulæ are very wide apart.

Height of the corallum $1\frac{1}{2}$ inch.

Locality. Bracklesham. Collected by the Rev. Osmond Fisher, F.G.S.

The coarse cœnenchyma and the size of the calices, with the nature of the encrusting base, distinguish this species from those already described.

IX.—LIST OF BRITISH TERTIARY CORALS FROM THE CRAG, BROCKENHURST BEDS, AND THE EOCENE OF THE ISLE OF WIGHT AND THE LONDON CLAY.

I.—No new species have been discovered in the British Crag since the publication of the Monograph of the British Fossil Corals by MM. Milne-Edwards and Jules Haime. Those noticed and described in that monograph are as follows :

1. *Sphenotrochus intermedius*, Münster, sp.
2. *Flabellum Woodi*, Edwards and Haime.¹
3. *Cryptangia Woodi*, Edwards and Haime.
4. *Balanophyllia calyculus*, Searles Wood.

¹ The species should be called *Flabellum semilunatum*, Wood, but doubtless Mr. Searles Wood will be satisfied with the distinction MM. Milne-Edwards and Jules Haime conferred on him.

II.—The following species have been described from the Brockenhurst beds :

1. *Solenastræa cellulosa*, sp. nov.
2. — *Koeneni*, „
3. — *Reussi*, „
4. — *gemmans*, „
5. — *Beyrichi*, „
6. — *granulata*, „
7. *Balanophyllia granulata*, „
8. *Lobopsammia cariosa*, Goldfuss, sp.
9. *Axopora Michelini*, sp. nov.
10. *Litharæa Brockenhursti*, „
11. *Madrepora Anglica*, „
12. — *Roemeri*, „
13. — *Solanderi*, Defrance.

III.—The following list includes all the species from the London Clay, the Bracklesham beds, and the Barton beds :

1. *Turbinolia sulcata*, Lamarck.
2. — *Dixoni*, Edwards and Haime.
3. — *Bowerbanki*, „
4. — *Fredericana*, „
5. — *humilis*, „
6. — *minor*, „
7. — *firma*, „
8. — *Prestwichi*, „
9. — *affinis*, sp. nov.
10. — *exarata*, „
11. — *Forbesi*, „
12. *Leptocyathus elegans*, Edwards and Haime.
13. *Trochocyathus sinuosus*, Brongniart, sp.
14. — *Austeni*, sp. nov.
15. — *insignis*, „
16. *Paracyathus crassus*, Edwards and Haime.
17. — *caryophyllus*, Lamarck, sp.
18. — *brevis*, Edwards and Haime.

19. *Paracyathus Haimei*, sp. nov.
20. — *cylindricus*, „
21. *Dasmia Sowerbi*, Edwards and Haime.
22. *Oculina conferta*, „
23. „ *incrustans*, sp. nov.
24. „ *Wetherelli*, „
25. *Diplohelix papillosa*, Edwards and Haime.
26. *Stylocænia emarciata*, Lamarck, sp.
27. — *monticularia*, Schweigger, sp.
28. *Astrocænia pulchella*, Edwards and Haime.
29. *Stephanophyllia discoides*, „
30. *Balanophyllia desmophyllum*, „
31. *Dendrophyllia elegans*, sp. nov.
32. — *dendrophylloides*, Lonsdale, sp.
33. *Stereopsammia humilis*, Edwards and Haime.
34. *Dendracis Lonsdalei*, sp. nov.
35. *Porites panicea*, Lonsdale.
36. *Litharæa Websteri*, Bowerbank, sp.
37. *Axopora Fisheri*, sp. nov.
38. — *Parisiensis*, Michelin, sp.

NUMBER OF SPECIES.¹

Crag	.	.	.	.	4.
Brockenhurst	.	.	.	.	13.
London Clay	}	.	.	.	38.
Bracklesham		.	.	.	
Barton		.	.	.	
Total Tertiary Species					55.

¹ The corals from Lenham and the ferruginous sands of the North Downs are only found as indeterminate casts.

PLATE I.

TO ILLUSTRATE THE STRUCTURE OF CORALS.

(See *Introduction*.)

FIG.

1. The calice of *Bathycyathus Sowerbyi*¹ (after Milne-Edwards and Jules Haime). The projection of the *costæ* externally and of the *septa* internally is shown; the existence of a *wall* between the junctions of the *septa* and *costæ* is evident. There is no *columella*.
2. The *costæ* running down the outside of the corallum of *Trochomilia tuberosa* (after Milne-Edwards and Jules Haime).
3. A section of a corallite of *Lophohelia anthophyllites*, Ellis, showing the dense *wall*, with the projection inwards of the *septa*. There are no *costæ*. From nature, magnified.
4. A corallite of *Cænocyathus Adamsi*, Duncan,² showing the *base*, the *body*, and the *calicular termination*. The base is rough, and was formerly strongly attached to a foreign substance; the body has a few aborted buds on it, and the upper extremity shows faint *costæ* terminating in *septa*.
5. A longitudinal section of *Sphenotrochus intermedius*³ (after Milne-Edwards and Jules Haime). The central styliform process is the *columella*; it arises from the base internally, and is joined to the *septa* by lateral processes. It is an "essential" *columella*. The *septa* are shown as broad plates, granulated and arched; they are attached externally to the wall. Outside the faint shading of the wall is the slight projection of one of the *costæ*. This corallite is open from the *calicular margin* to the *base*.
6. The calice of *Placotrochus costatus*, Duncan.⁴ The upper and free surface of a long *columella* is shown, also the same structures as in fig. 1. Magnified.
7. The external surface of the same coral, showing the irregular *calicular margin*, the strong *costæ*, and the delicate *peduncle* of the *base*.
8. Part of a calice of *Placocyathus Moorei*, Duncan,⁵ showing the *costæ*, *septa*, and part of a long *columella*, as in fig. 6; but there are *pali* on the ends of four of the *septa*. Magnified.
9. The calice of *Trochocyathus obesus*⁶ (after Milne-Edwards and Jules Haime), magnified. The larger *septa* are separated by three smaller, of which the middle one is the longest. There are twelve large *septa*, and every other one is a primary septum. The *pali* are before the primary, the secondary, and the tertiary *septa*. There are four cycles of *septa*.
10. The calice of *Discocyathus Eudesii*⁷ (after Milne-Edwards and Jules Haime), magnified. The *columella* is lamellar, and the large *pali* are before the antepenultimate cycle (or the third). There are five cycles.
11. Two corallites of *Heliastrea endothecata*,⁸ Duncan, magnified. The *costæ* seem to be united by transverse exothecal dissepiments, and the tooth of a small *costa* projects in the space formed by the dissepiments and the *costæ*. Some cœnenchyma exists between the corallites.
12. A longitudinal section of *Conosmilia anomala*,⁹ Duncan, magnified. The twisted processes forming the essential *columella* are seen, and one side of the lamina of a septum. This is granular, and is marked by a broken ridge, which once was continued to the next septum as a dissepiment. The wall is seen externally.
13. A section of a corallite of *Calamophyllia Stokesi*¹⁰ (after Milne-Edwards and Jules Haime), magnified. The formation of a rudimentary *columella* is shown, and the sections of oblique dissepiments between the *septa* and crossing the interseptal loculi are seen.
14. A longitudinal section of the upper part of a corallum of *Caryophyllia cyathus*¹¹ (after Milne-Edwards and Jules Haime), magnified. The wall is the external and structureless part, and it has no *costæ* projecting from it. The lateral view of the *septa* shows them to be granular, arched above, and slightly exsert. The *pali* are attached to the inner margin of the *septa* and to the outer part of the *columella*, which is formed by many twisted processes. A line drawn from the top of opposite *septa* forms the upper limit of the *calicular fossa*, and whose base is the top of the *columella* centrally, and the top of the *pali*. There are no dissepiments.
15. A longitudinal section of part of the corallum of *Antillia Lonsdaleia*,¹² Duncan, magnified. The thin wall gives off internally many dissepiments, which are joined by their side to the septum. Externally, it is in contact with a few oblique exothecal dissepiments. The granulated structure crossed by the exotheca, and external to the wall, is a *costa*, and is seen to emerge into a septum superiorly. The septum is very exsert, is bilobate, dentate, and is marked by radiating ornamental ridges. The *columella* is dense. The endotheca is vesicular.
16. A corallum of the genus *Montlivaltia*, showing the epitheca with circular rings.
17. A diagram of the relation of the hard and soft parts of a coral. The parts shaded are the wall, the part of the sclerenchyma below the newest dissepiment, and the *columella*. All the rest is in contact with soft tissues. The mouth and tentacles are shown.
18. A diagram of the hard parts of a coral. The living tissues only cover the portion above the topmost exothecal and endothecal dissepiments. The base is pedunculate, and embraces a foreign substance; the *columella* springs from the inside of the base, and is in contact laterally with the *pali*. The *septa*, wall, *costæ*, endothecal and exothecal dissepiments, are shown, and the trace of an epitheca quite externally and inferiorly also.
19. Corallites of a *Sarcinula*¹³ (after Milne-Edwards and Jules Haime), united by peritheca; the *costæ* are rudimentary.

¹ 'Brit. Foss. Corals,' tab. ii.

² "Corals of Maltese Miocene," 'Ann. Mag. Nat. Hist.,' s. 3, vol. xv, pl. xi.

³ 'Brit. Foss. Corals,' tab. i, fig. 5.

⁴ Duncan and Wall, Jamaica, 'Quart. Jour. Geol. Soc.,' Feb., 1865.

⁵ Duncan and Wall, op. cit.

⁶ 'Ann. des Sciences Nat.,' 3me série, "Zool.," tom. ix, pl. x, fig. 2.

⁷ Ibid., pl. ix, fig. 7.

⁸ Duncan, "Foss. Corals of West Indies," 'Quart. Jour. Geol. Soc.,' Nov., 1863, vol. xix, p. xv.

⁹ Duncan, "Foss. Corals of Australian Tertiaries," 'Ann. Mag. Nat. Hist.,' Sept., 1865.

¹⁰ 'Brit. Foss. Corals,' part iii.

¹¹ 'Ann. des Sci. Nat.,' ut supra, tom. ix, p. 85.

¹² 'Foss. Corals of West Indies,' part ii, pl. iii.

¹³ 'Ann. des Sci. Nat.,' ut supra, tom. x, pl. vi.

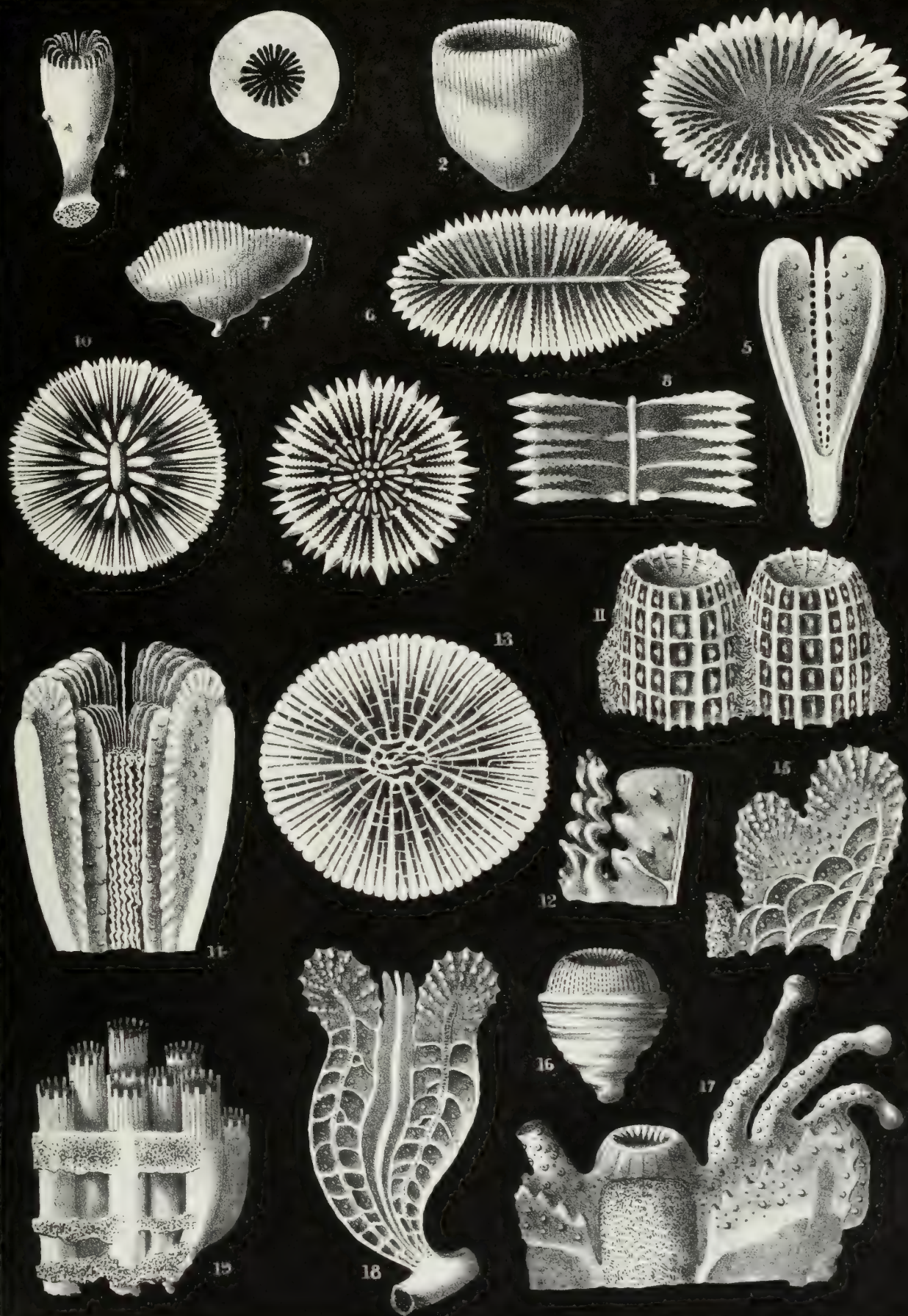


PLATE II.

TO ILLUSTRATE THE STRUCTURE OF CORALS.

FIG.

- 1 to 8, and fig. 19. The soft parts of *Cladocora cæspitosa*¹ (after Jules Haime). Fig. 4. The tentacles, tentacular disc, mouth, and radiating lines on the lips. Fig. 3. Magnified view of a section of part of a tentacule; the arrangement and nature of the nematocysts and of the large transparent vesicles of the verrucose prominences are shown; the structure of the internal layer, with its colour-bearing cells, is also shown. Fig. 1. A portion of the terminal swelling of a tentacule; the two kinds of nematocysts are very well seen. Figs. 5, 6, 7, 8. Nematocysts of the terminal swelling. Fig. 2. The tubular processes attached to mesenteric folds; they are covered with cilia, and contain nematocysts. Fig. 19. A portion of a tentacule, magnified, showing the terminal swelling and the verrucose swellings.
- 9, 11, 12, 15, 18, 20.² The soft tissues of *Caryophyllia clavus (borealis)*. Fig. 12. The polype attached to a Ditrupa by a fine peduncle; the costæ are seen to be covered with a transparent tissue, which gives them a rounded outline; the tentacles overlap the calicular margin, and are fully expanded (slightly magnified). Fig. 9. The tentacles of various orders fully expanded, the central mouth, the lips, and the disc immediately around them, with the radiating lines, are shown. The hard parts of the calice are completely covered and hidden. Fig. 11. A magnified view of the tentacular disc, the tentacles not being fully expanded. The septa are seen, but are covered with soft tissue. The mouth, lips, and disc, with the radiating lines, are shown.
15. The top of a tentacule, magnified, showing scutiform processes analogous to the verrucose projections of *Cladocora*. Figs. 18 and 20. The same processes, highly magnified.
10. The tentacular discs³ of the corallites of *Heliastræa cavernosa*, magnified. The mouth is projected on a truncated process, and the tentacular development is small.
13. *Lithophyllia Cubensis*,⁴ in the living state. The costæ are quite hidden by the soft parts, and the large disc, with its central mouth and radiating lines, is seen. The base is very broad.
14. *Colpophyllia gyrosa*,⁵ from a living specimen. The three mouths to a part of a serial calice.
16. *Manicina areolata*,⁶ showing the relation of the tentacles to the mouths in the serial calice.
17. A coral of the same species,⁷ with the prehensile cirrhi fully expanded. The tentacles are small, and there are two mouths to the serial calice.

¹ 'Hist. Nat. des Corall.,' vol. ii, plate, A, iv.

² These beautiful illustrations were drawn for me, from nature, by Mr. Peach, who also gave me his notes on the anatomy of the *C. borealis*, Fleming.

^{3 4 5 6 7} The figures are after Michelotti et Duchassaing, op. cit., pl. v.

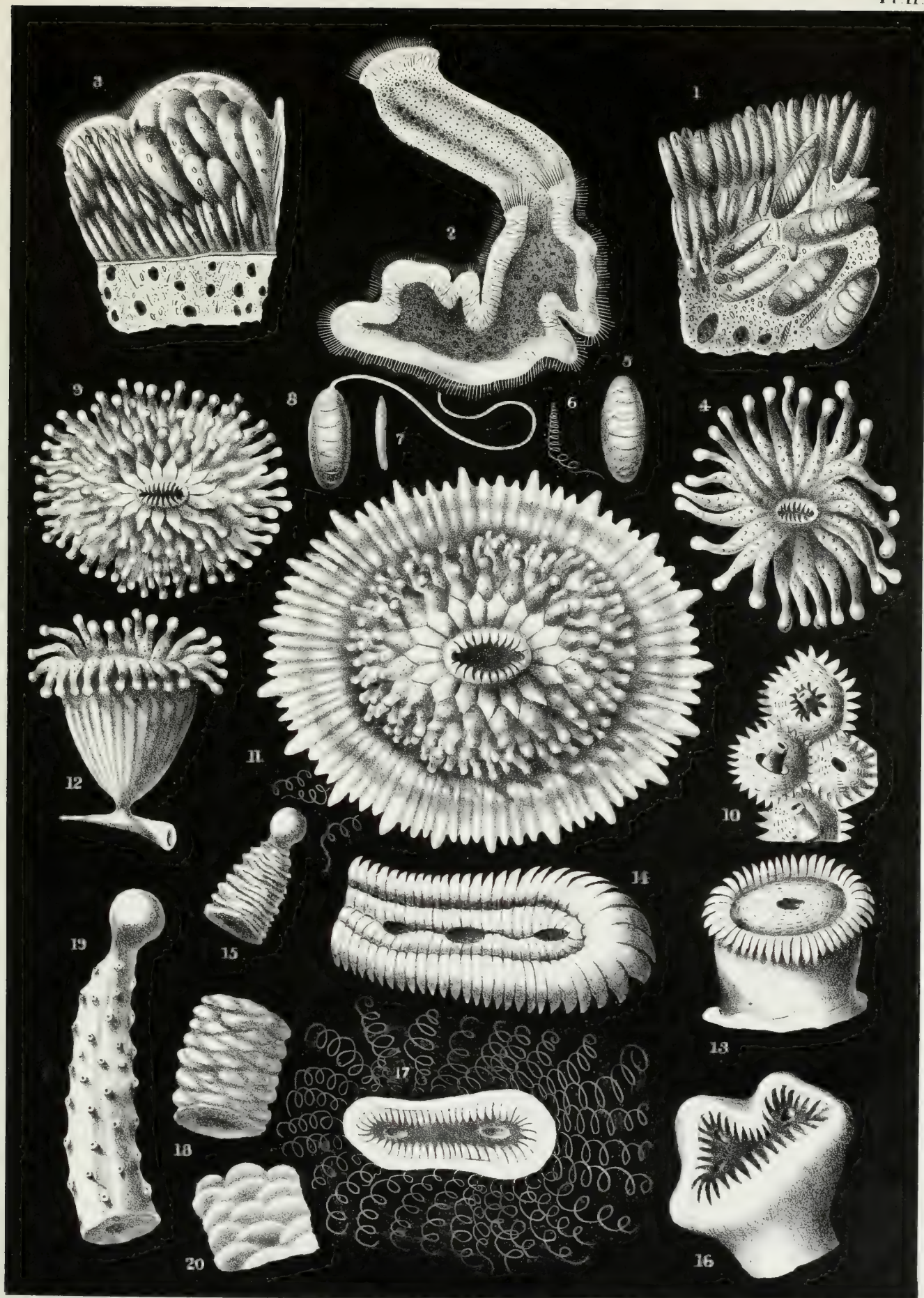


PLATE III.

TO ILLUSTRATE THE STRUCTURE OF CORALS.

FIG.

- 1, 2, and 7. These illustrate the nature of synapticulæ, from species of *Micrabacia* and *Mycedium*. The cross bars are not in the nature of dissepiments, and must not be considered to be the upper surfaces of very oblique or nearly vertical dissepiments.
3. Corallites of *Alveopora dædalæa*,¹ showing the regular perforations in the wall, constituting the species a "perforate" or porose coral.
4. The perforate septa and walls of *Litharæa Websteri*. Compare these cribriform septa with those of *Sphenotrochus intermedius* in Plate I, fig. 5.
5. The wall, septa, and false columella of *Alveopora fenestrata*.²
6. The structure of the septa of the same coral seen longitudinally. They consist of a simple series of projections, and do not form a continuous plate or lamina.
8. The calice of *Pocillopora crassoramosa*,³ showing a horizontal dissepiment (a tabula) closing the calice below. It is marked by faint septa near the calicular margin; the cœnenchyma external to the calice is very dense and granular.
9. A diagram of a longitudinal section of the same species. The tabulæ with arched superior surfaces and the dense cœnenchyma with its granules are shown.
10. The tubuliform structures marked across by lines are corallites of *Heliolites Murchisoni*; the tabulæ represented by the lines are close; the wall of the corallites is very slender, and there is much cellular cœnenchyma between the corallites.
11. A longitudinal section of a tabulate coral, a *Favosites*. There is no cœnenchyma, but the walls are fused.
12. Calices of *Heliolites interstincta*, magnified. The cœnenchyma is cellular.
13. Calices of an *Alveolites*.
14. Perforate walls of a *Favosites*.
15. A calice of *Stauria astrææformis*,⁴ with three calicular buds. The quadrisepate arrangement is very evident. Magnified.
16. Longitudinal section of a corallite of the same species.⁵ The dense walls, the endotheca forming cellular dissepiments externally and horizontal tabulæ internally, and the septa, are shown. Magnified.
17. The calice of *Anisophyllum Agassizi*,⁶ magnified, showing three large septa.
18. The calice of *Cyathaxonia cornu*,⁷ magnified.
19. The calice of *Aulacophyllum mitratum*,⁸ magnified.
20. The calice of *Ptychophyllum expansum*.⁹

¹ 'Foss. Corals of West Indies,' pl. xiv.

² 'Ann. des Sc. Nat.,' t. ix, pl. v.

³ 'Fossil Corals of West Indies,' pt. ii, pl. 5.

⁴⁻⁹ Selected from 'Polyp. Foss. des Terr. Paléo.,' MM. Milne-Edwards et Jules Haime; they are intended to illustrate the Introduction which will appear when the palæozoic species are described.

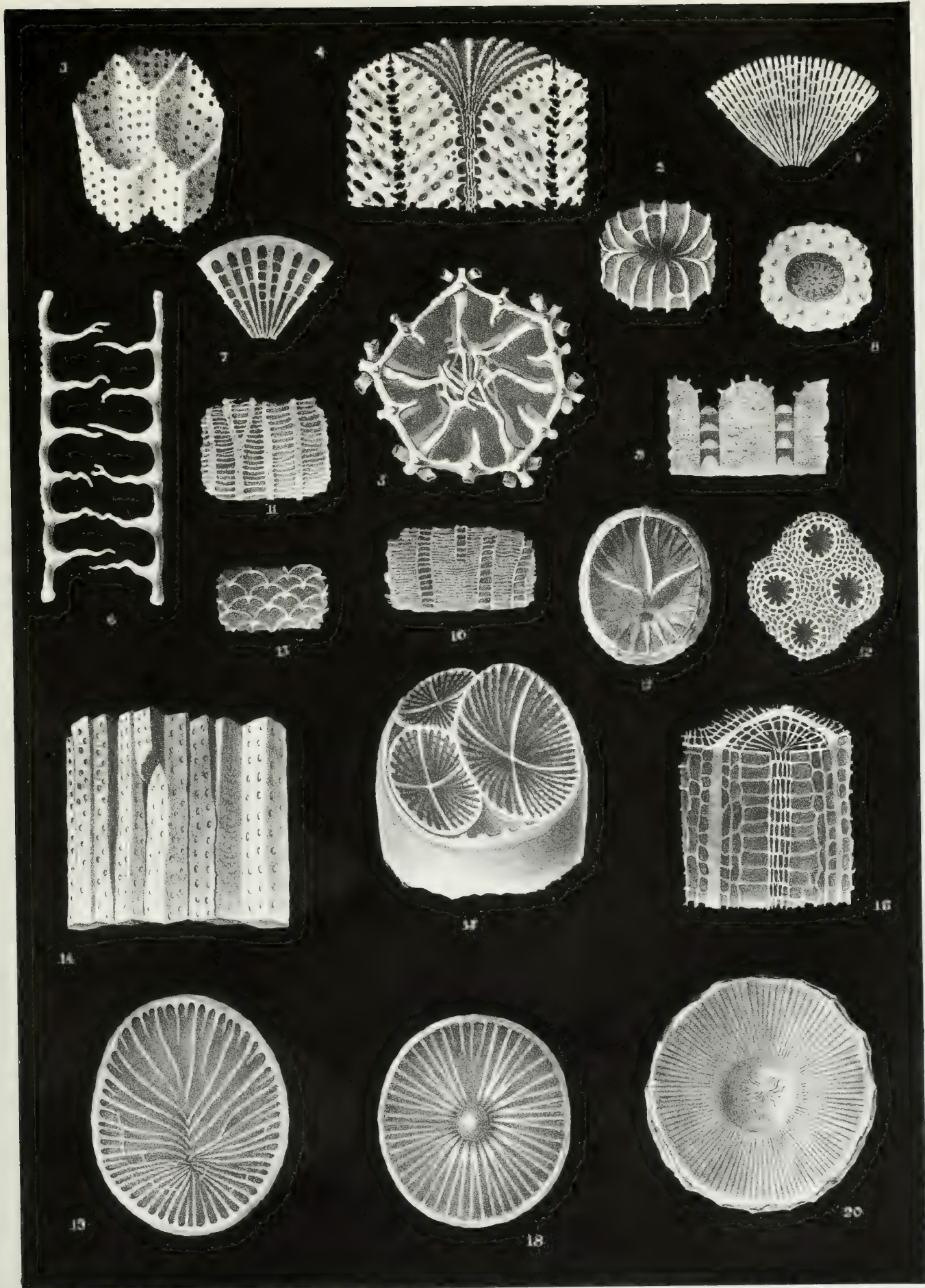


PLATE IV.

TO ILLUSTRATE THE STRUCTURE OF CORALS.

FIG.

1. Magnified view of part of a transverse section of the corallum of *Antillia Walli*.¹ The upright plates are septa, and the lowest structure at right angles to the septa, and which has its lower margin somewhat wavy, is part of the epitheca. The structure parallel with the epitheca, and separated from it by the short costæ and intercostal spaces, is the true wall. Higher up are two transverse dense layers of sclerenchyma; they spread from septum to septum across the interseptal loculi and simulate secondary walls. They are highly developed masses of dissepiments, whose intercellular spaces have been filled up with carbonate of lime.
2. A longitudinal section of part of a corallite of *Lonsdaleia Bronni*,² magnified. The columella has been removed. The tabulæ are seen stretching across, but not interfering with the growth of the septa; externally, the vesicular endotheca partly produces a false wall. The dense wall is shown.
- 3 and 4. Examples of inner and outer walls in Rugose corals.
5. The septa and the cut edges of oblique dissepiments in a large species of *Zaphrentis*, from nature.
6. Part of a corallite of *Zaphrentis gigantea*,³ showing the granular epitheca, the slight true wall, the septa, and the interseptal loculi, with dissepiments.
7. Calices and cœnenchyma of *Lyellia Americana*,⁴ magnified.
8. Calicinal gemmation in a *Caryophyllia*; it is fatal to the parent, and is accidental. From nature.
- 9 and 10. Calicinal gemmation in a *Cyathophyllum*. The normal and the budding corallites are shown.
11. Calicinal gemmation close to the margin, in the genus *Isastræa*, magnified.
12. Fissiparous division of calices in *Dichocænia*.
13. Fissiparous division of calices in *Leptastræa Roissyana*,⁵ magnified.
14. A serial calice of the genus *Thysanus*.
15. Calices (serial) of a *Mæandrina*.
16. An example of extracalicular gemmation, from nature.
17. A corallum of *Oculina Halensis*. The centre is occupied by the parent stem, and the buds radiate from it.⁶
18. A section of a branch of a species of *Madrepora*, magnified. The parent corallite occupies the centre, and the younger arise from it more or less at right angles. The peculiar septal arrangement of the genus and the porose condition of the sclerenchyma are shown. From nature.

¹ Duncan and Wall, op. cit., pl. ii.

^{2 3 4} From 'Polypiers Fossiles des Terr. Pal.,' MM. Milne-Edwards et Jules Haime.

⁵ 'Ann. des. Sc. Nat.,' t. x, pl. ix.

⁶ "Foss. Corals from Sinde," 'Ann. and Mag. Nat. Hist.,' &c., April, 1864.

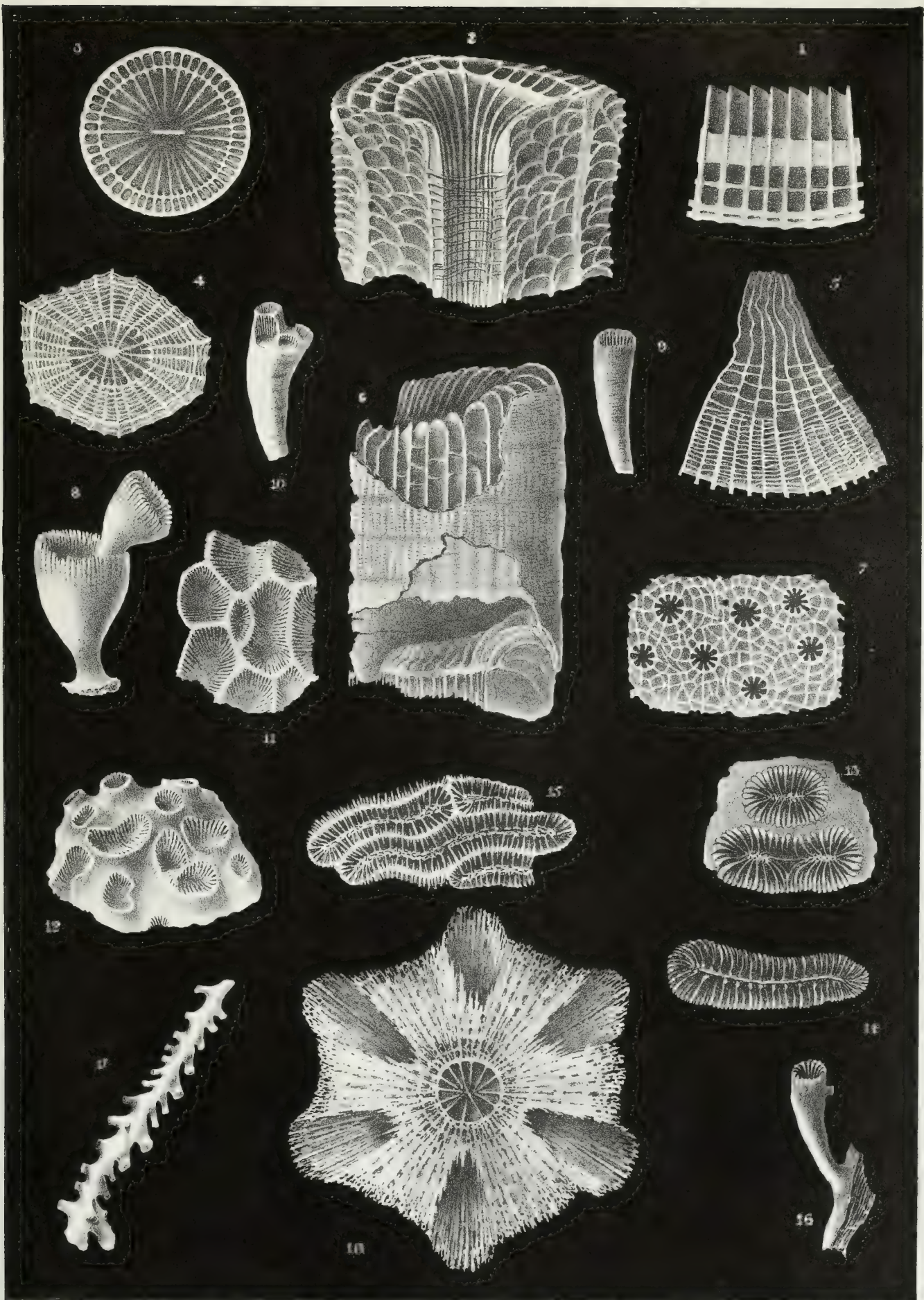


PLATE V.

CORALS FROM BROCKENHURST.

Solenastræa cellulosa, Duncan. (P. 41.)

FIG.

1. View of the upper surface of the corallum.
2. Lateral view, showing the cellular exotheca.
3. One system, with its four cycles; the abundant endotheca is shown, also the rudimentary costæ. Much magnified.
4. A transverse section of a corallite close to the calice, magnified.
5. A lateral view of a corallite covered with exotheca, magnified.
6. Part of a corallite above the exotheca, and showing the costæ; magnified.
7. View of the upper surface, magnified.

Solenastræa Koeneni, Duncan. (P. 42.)

8. The corallum.
9. A calice, highly magnified.

Solenastræa Reussi, Duncan. (P. 43.)

10. The corallum, showing the banded exotheca.
11. Costæ; there is exotheca above and below them.
12. Upper surface of corallum, highly magnified, showing the granular surface of the upper layer of the exotheca, the banded structure of part of the exotheca, and the calices.
13. Upper surface of corallum, worn.
14. Exotheca, cellular and banded.
15. Side view of one of the septa, magnified.
16. One system of septa, showing five cycles.

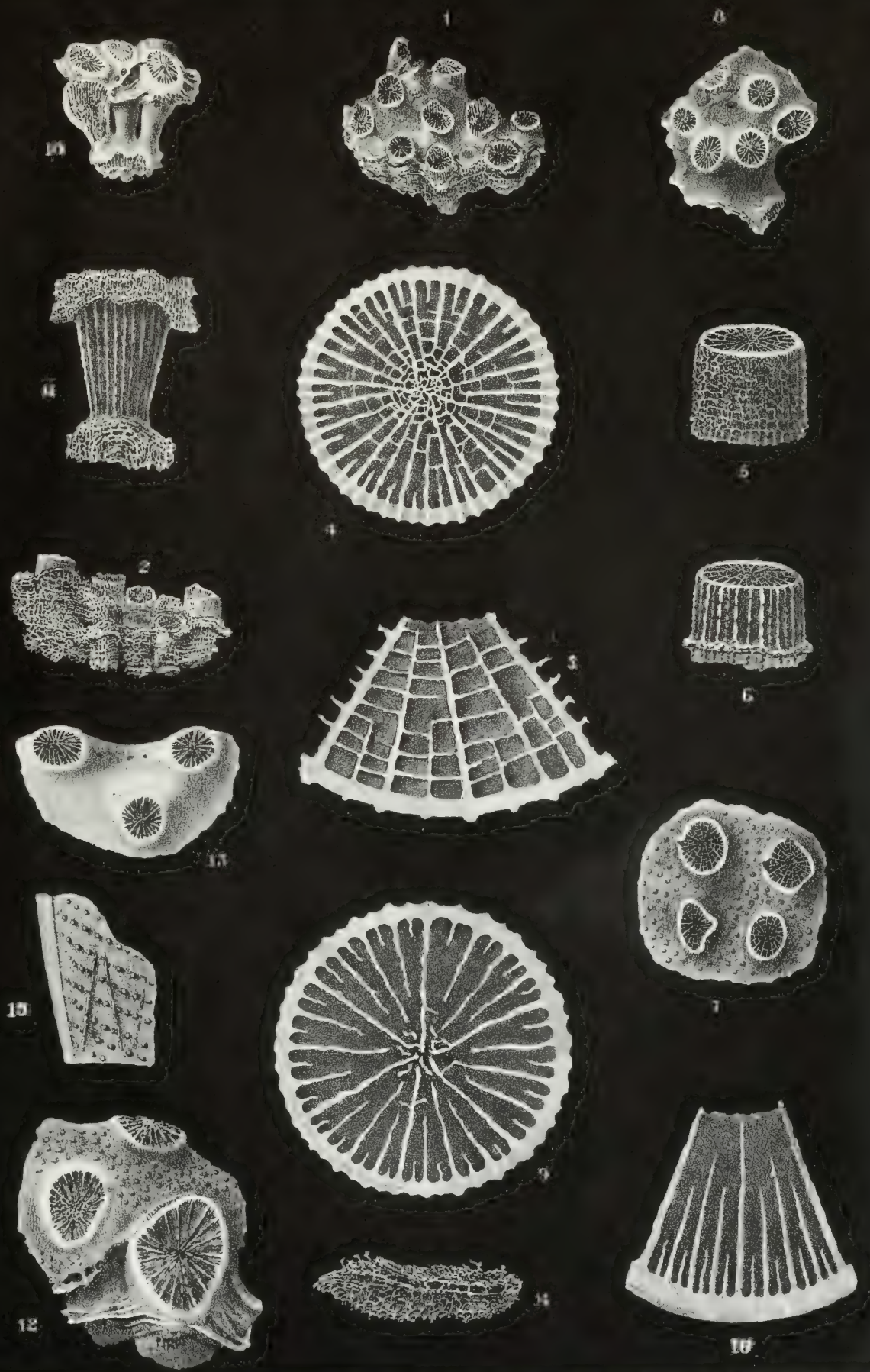


PLATE VI.

CORALS FROM BROCKENHURST.

Solenastræa gemmans, Duncan. (P. 44.)

FIG.

1. The corallum, a side view.
2. Corallites showing the method of gemmation, slightly magnified.
3. Costæ, magnified.
4. Two corallites, united by exotheca, magnified.
5. A view a little below the calice, magnified.
6. One of the septa; the lateral processes join endothecal dissepiments.
7. Granular and endothecal markings on the side of one of the septa, magnified.

Solenastræa Beyrichi, Duncan. (P. 44.)

8. The corallum, its upper surface.
9. Lateral view of corallites and exotheca, slightly magnified.
10. One of the septa, showing the thick wall and inclined endotheca, magnified.
11. Costæ, thick wall, and septa, magnified.
12. Transverse section, close to a calice, magnified.
13. A deformed calice, magnified.

Solenastræa granulata, Duncan. (P. 45.)

14. Upper surface of a worn corallum.
15. Cellular and banded exotheca uniting corallites, magnified.
16. Corallite wall without exotheca; exotheca in cells and bands; the costæ are also shown. Magnified.
17. Transverse section of a corallite, magnified.
18. The septa at the calicular margin, showing the paliform lobe, magnified.

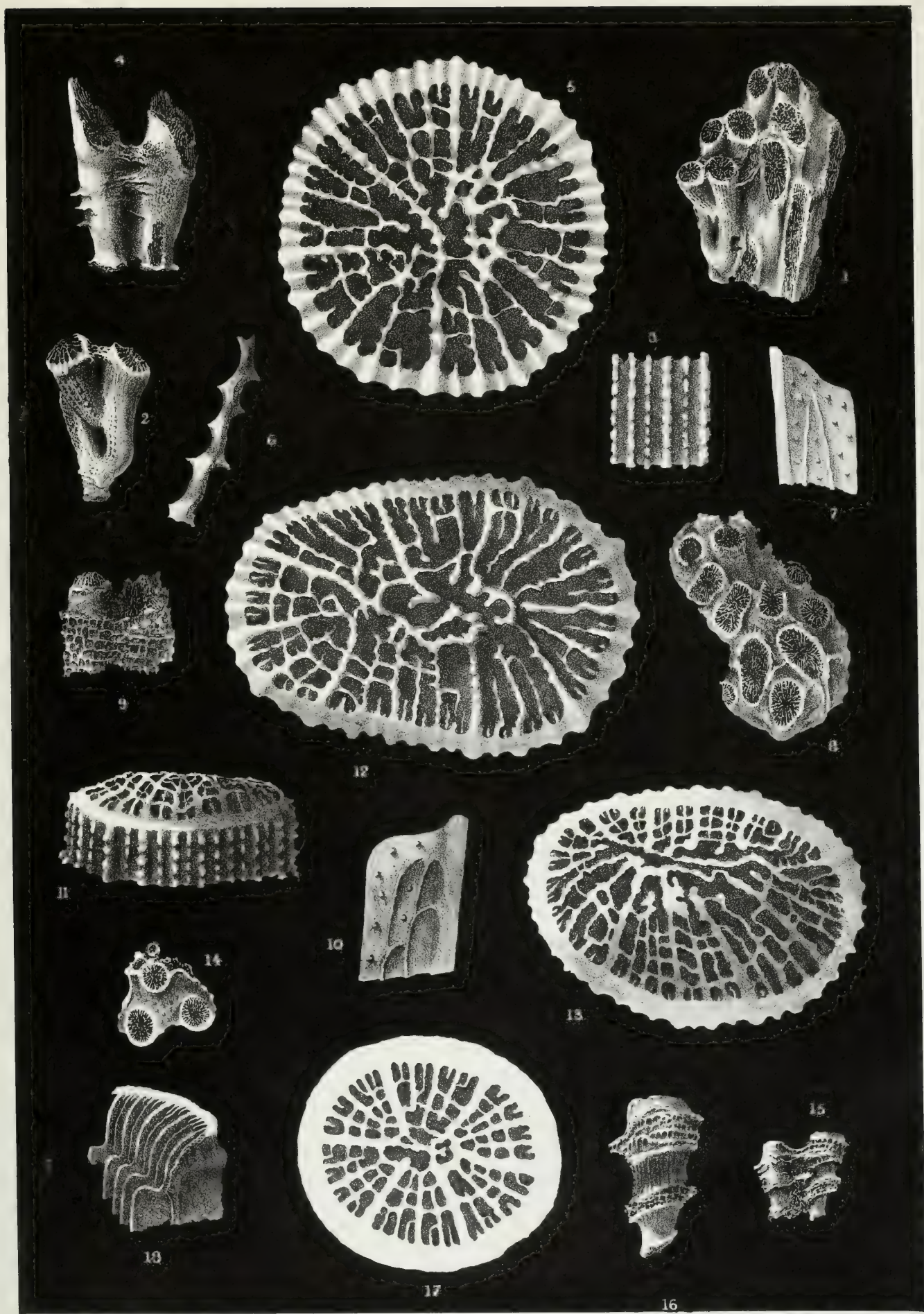


PLATE VII.

CORALS FORM BROCKENHURST.

Balanophyllia granulata, Duncan. (P. 47.)

FIG.

1. The corallum fixed to a shell.
2. General view of the costæ, magnified.
3. Larger or inferior end of the costæ, magnified.
4. Costæ higher up, magnified, to show their granules.
5. The rough and elevated granular surface of the smaller costæ, magnified.

Lobopsammia cariosa, Goldf., sp. (P. 48.)

6. Lateral view of a corallum.
7. Costæ, magnified.
8. A corallum with fissiparous calices.
9. A fissiparous calice, magnified.
10. The base of a corallum.

Axopora Michelini, Duncan. (P. 50.)

11. Corallum.
12. Magnified view of calices, with the columella and cœnenchyma.
13. Magnified view of corallites in longitudinal section.
14. Columella, tabulæ, and cœnenchyma, highly magnified.
15. Longitudinal view of corallites in longitudinal section, magnified. (Figs. 13 and 15 are from a variety.)

Litharæa Brockenhursti, Duncan. (P. 49.)

16. Calices, magnified.
17. A calice, highly magnified.

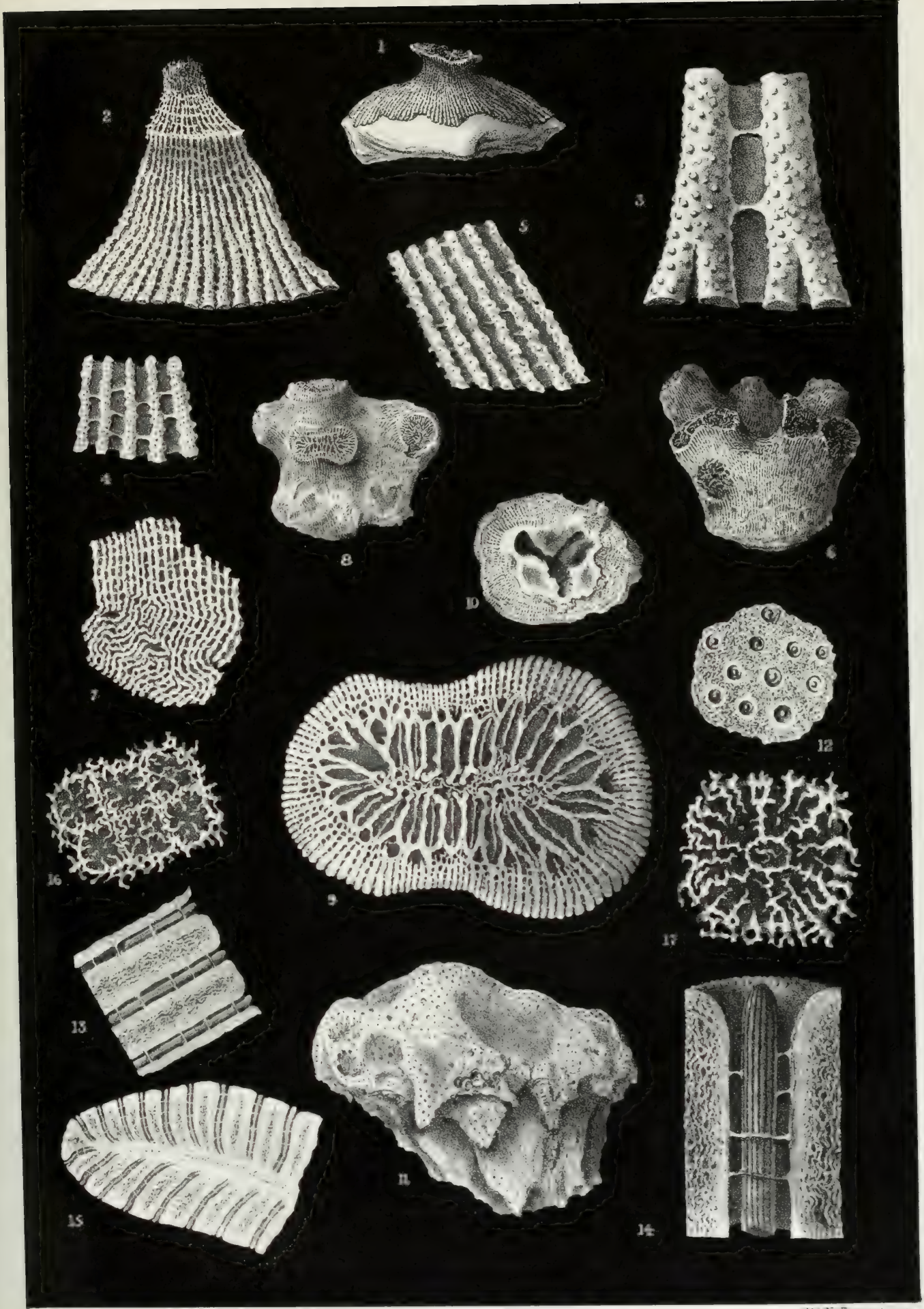


PLATE VIII.

CORALS FROM BROCKENHURST.

Madrepora Anglica, Duncan. (P. 51.)

FIG.

1. The corallum.
2. Group of calices from the end of an aborted branch; the union of opposite primary septa is well seen. Magnified.
3. A diagram of the septal arrangement, the wall, and the faint costæ.
4. Slightly projecting calices, separated by much papillate cœnenchyma, magnified.
5. One of the calices, magnified, showing the papillate cœnenchyma also.
6. Longitudinal section of two corallites and the intervening cœnenchymal cells; the papillæ on the surface are shown. Magnified.
7. Magnified view of a projecting tubuliform calice, with costæ ending inferiorly in the cœnenchymal papillæ.

Madrepora Roemeri, Duncan. (P. 51.)

8. The coalesced branches of part of the corallum.
9. Diagram of the septal arrangement.
10. A tubuliform calice, with projecting costæ, magnified.
11. A branch (worn), magnified.

Madrepora Solanderi, DeFrance. (P. 51.)

12. Part of a corallum.
13. Group of calices, magnified.
14. Group of calices and surrounding granular cœnenchyma, magnified.





PLATE IX.

CORALS FROM HIGH-CLIFF, BROOK, BRACKLESHAM, BRAMSHAW, AND BARTON.

Turbinolia affinis, Duncan. (P. 54.)

FIG.

1. Corallum, natural size.
2. Corallum, highly magnified.
3. Calice, magnified.

The costal markings are shown in fig. 2.

Turbinolia exarata, Duncan. (P. 55.)

4. Corallum, natural size.
5. The same, highly magnified.
6. The calice, highly magnified, showing the projecting costæ, the thin wall, and the small columella.
7. The rudimentary exotheca on the side of one of the costæ, and its attachment to the thin wall. The portion of the wall is at the bottom of an intercostal space. Magnified.

Turbinolia Forbesi, Duncan. (P. 55.)

8. Corallum, natural size.
9. The same, magnified; the rudimentary costæ are seen between those well developed, close to the calicular margin.
10. Calice, magnified, showing the irregular septal arrangement, the rudimentary costæ, and the angular shape of the columella.
11. A part of a calice, highly magnified, to show the rudimentary and the perfect costæ; the rudimentary costæ are sharp, and have no septa.

Paracyathus Haimei, Duncan. (P. 59.)

12. Corallum, natural size.
13. The calice, magnified. It is worn.
14. Costæ, magnified. The exotheca is shown.

Trochocyathus Austeni, Duncan. (P. 57.)

15. Corallum.
16. Calice, magnified.
17. One of the septa joined to a costa, showing the spinules; magnified.

Paracyathus cylindricus, Duncan. (P. 58.)

18. Corallum, natural size; adult.
19. Young corallum.
20. Calice, magnified.
21. Side view of a magnified septum, showing the large granules.

Oculina incrustans, Duncan. (P. 60.)

22. Part of a corallum, slightly magnified.
23. Part of a corallum, showing the faint costal striæ and the absence of granules; slightly magnified.
24. Calice, much magnified.

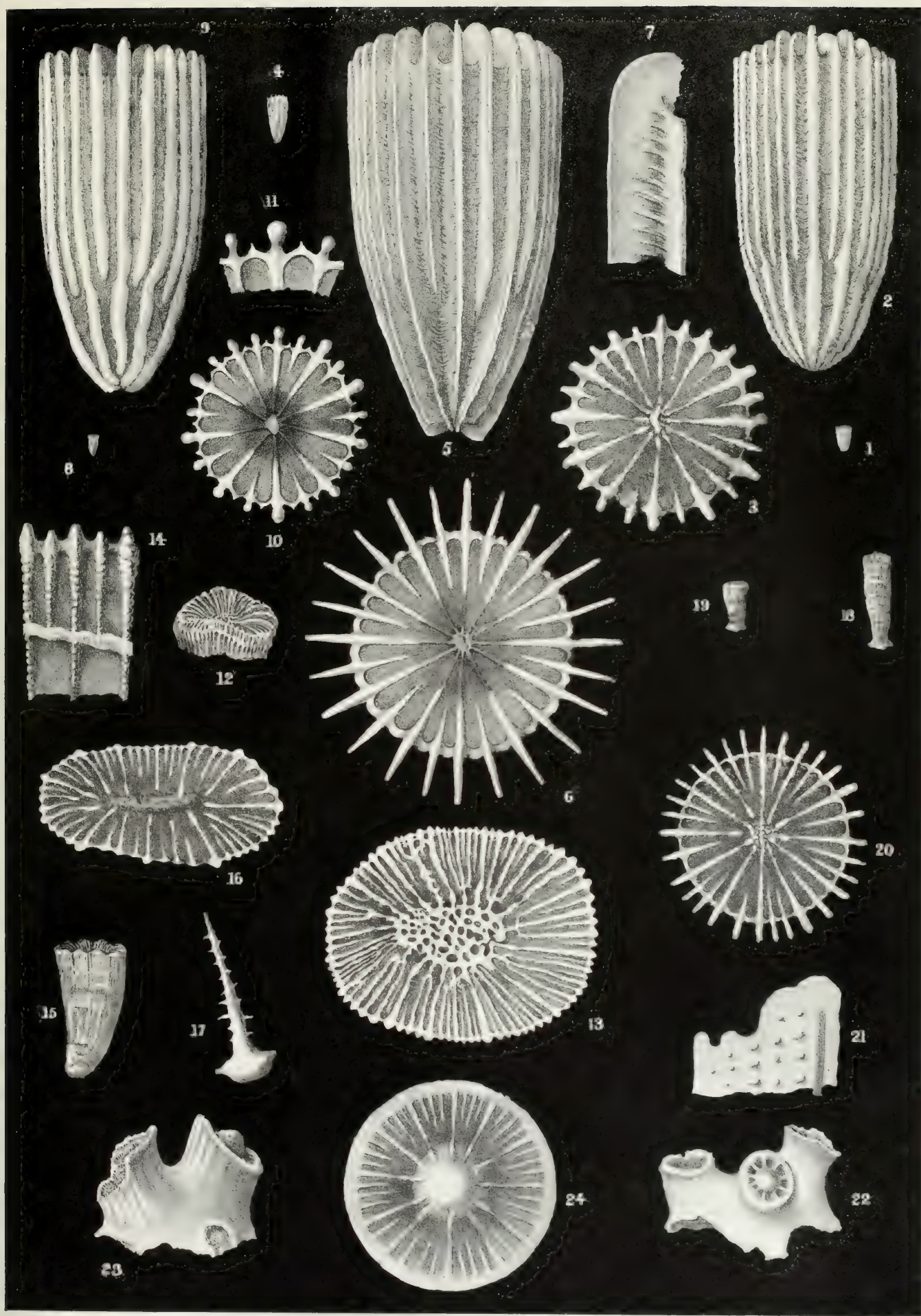


PLATE X.

CORALS FROM BRACKLESHAM, WHETSTONE, AND FINCHLEY.

Trochocyathus insignis, Duncan. (P. 57.)

FIG.

1. Corallum.
2. The calice, magnified.
3. One of the septa, magnified, to show the lateral spinules and the wavy shape.
4. Costæ, magnified (at the calicular margin).

Oculina Wetherelli, Duncan. (P. 60.)

5. } Corallites, showing the broad base.
6. }
7. The calice, magnified.

Porites panicea, Lonsdale. (P. 63.)

8. Corallum.
9. Calices and intercalicular tissue, magnified, showing the columella, pali, and granules.
10. The inter-corallite tissue, magnified.

Dendracis Lonsdalei, Duncan. (P. 62.)

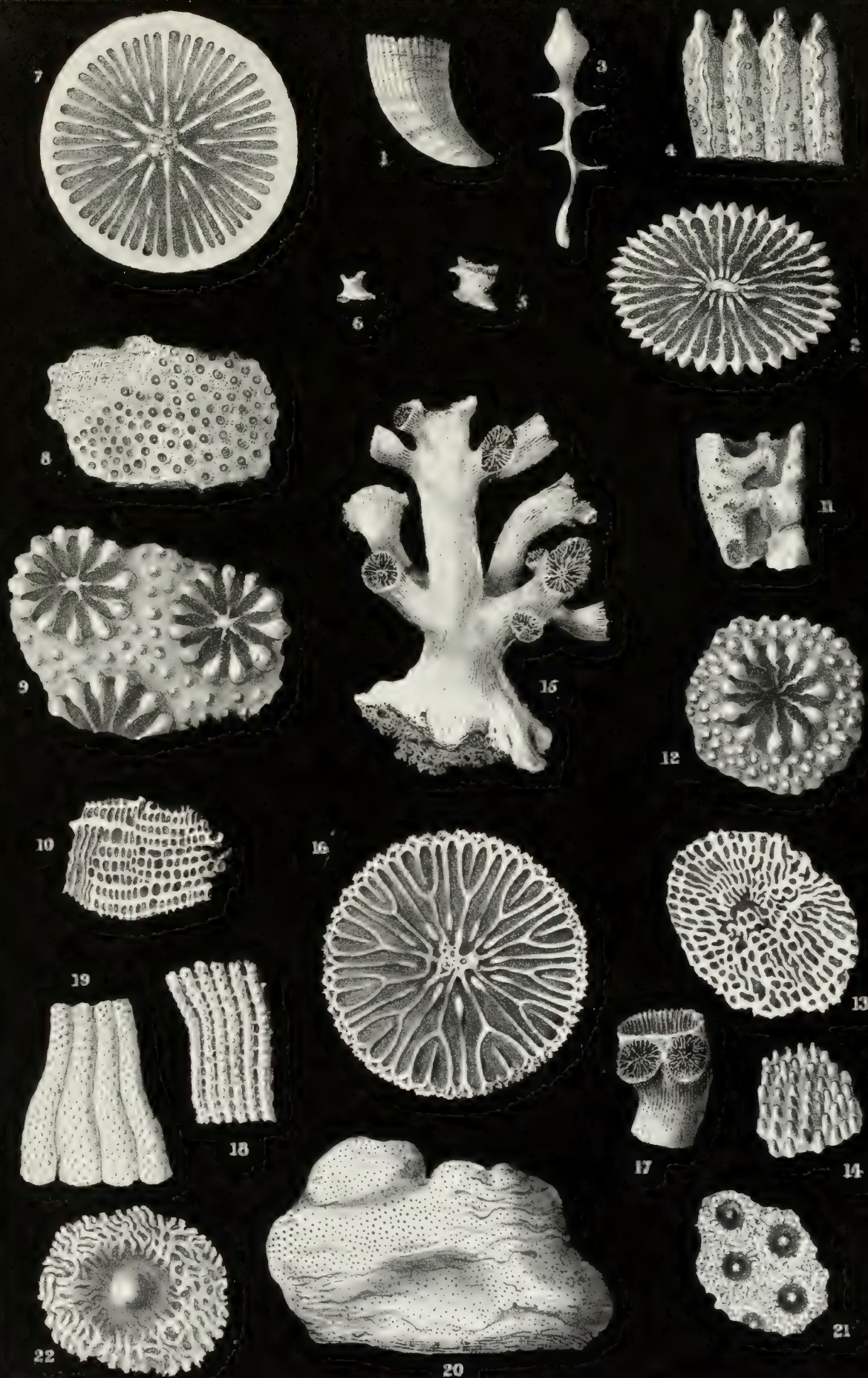
11. Corallum, natural size.
12. Calice, highly magnified, showing the granules around the calice.
13. Transverse section of a branch of the corallum, showing its reticulate appearance.
14. Intercalicular or cœnenchymal granules, highly magnified.

Dendrophyllia elegans, Duncan. (P. 61.)

15. Corallum.
16. A calice, highly magnified.
17. The method of gemmation.
18. Costæ, near the calices, magnified.
19. Costæ, near the base, magnified.

Axopora Fisheri, Duncan. (P. 64.)

20. Corallum.
21. Calices and intercalicular tissue, magnified.
22. A calice, columella, and cœnenchyma, highly magnified.



THE
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MDCCCLXVI.

A MONOGRAPH
OF THE
BRITISH FOSSIL CRUSTACEA,

BELONGING TO THE
ORDER MEROSTOMATA.

PART I.
[PTERYGOTUS ANGLICUS, *Agassiz*.]

PAGES 1—44; PLATES I—IX.

BY
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A MONOGRAPH
OF THE
BRITISH FOSSIL CRUSTACEA
OF THE
ORDER MEROSTOMATA.

PART I.

INTRODUCTION.

THE history of the Fossil CRUSTACEA of the British Islands cannot any longer be spoken of as a neglected subject.

Apart from the numerous papers thereon which have appeared in the various publications of the day, no fewer than ten Monographs of this class have been issued by the Palæontographical Society alone,¹ and one by the Geological Survey

¹ 'On the Cretaceous Entomostraca,' by Prof. T. Rupert Jones, F.G.S., &c., 1849

'On the Tertiary Entomostraca,' by the same Author, 1856.

'On the Fossil Estheriæ,' by the same Author, 1862.

'On the Fossil Lepadidæ,' by Charles Darwin, F.R.S., F.G.S., 1851.

'On the Fossil Balanidæ and Verrucidæ,' by the same Author, 1854.

'On the Crustacea of the London Clay,' by Prof. Bell, F.R.S., F.G.S., &c., 1858.

'On the Crustacea of the Gault and Greensand,' by the same Author, 1862.

'British Trilobites,' by J. W. Salter, A.L.S., F.G.S., 1864.

„ Part ii, by the same Author, 1865.

„ Part iii „ 1866.

of Great Britain;¹ to this latter work especial reference will frequently be made hereafter.

The *Crustacea* are included in the sub-kingdom ARTICULATA, and are characterised by a body divided into rings or segments, more or less distinct and moveable, and protected by a horny or calcareous exo-skeleton, provided with articulated limbs arranged in pairs, usually five² to seven³ in number.

The class is essentially aquatic, breathing by branchiæ; and, although some members subsist on land, their organs of respiration are true branchiæ, and quite dissimilar from the tracheæ of insects.

Before attaining the adult condition the marine species pass through a series of embryonic changes, apparently more numerous in the higher forms.⁴ Every part that is present in the larva, though not permanent in the individual, is to be found in a permanent condition in one or other form of adult *Crustacea* of a lower order than that to which it belongs.⁵

Even after arriving at the adult state the shelly envelope is not permanently retained, but is exuviated as often as the growth of the animal necessitates its enlargement. In the perfect Insect, on the contrary, the exo-skeleton is retained, and no increase of growth or reproduction of lost appendages takes place in the *imago*, as among mature *Crustacea*.

Previous to describing the order which forms the subject of this Monograph, it will be well to speak of the type on which the class is constructed. By the 'type,' we understand that example of any natural group which possesses all the leading characters of that group. For it must be borne in mind, that every division of animals, whether vertebrate or invertebrate, necessarily includes within its limits genera most dissimilar from the type-form upon which the class is constructed. No one, for example, would select the *Ornithorhynchus* as a typical mammal, or the *Apteryx* as a typical bird, the tunicated *Botryllus* as a type-mollusk, or the *Balanus* as a type-crustacean.

Indeed, the type of any class or order is not to be sought for at the extremity of the series, but near the centre.

Dr. Milne-Edwards⁶ writes, "The normal number of segments is twenty-one." . . . "By general consent and usage three regions are recognised in the bodies of

¹ 'Memoirs of the Geol. Survey of the United Kingdom,' Monograph I, 1859. "On the Anatomy and Affinities of the Genus *Pterygotus*," by Prof. T. H. Huxley, F.R.S., &c., with "Descriptions of the Species," by J. W. Salter, F.G.S., A.L.S.

² In the *Decapoda*.

³ In the *Isopoda*.

⁴ The land and freshwater *Decapoda*, as well as the sessile-eyed forms, apparently undergo these embryonic changes in the ova, the young nearly resembling the parent when excluded from the egg. See also Prof. Bell's "Hist. Brit. Stalk-eyed Crustacea," Introduction, pp. xlv—xlvi; and Prof. Owen's Lectures, 1855, pp. 334-342.

⁵ Spence Bate, "On the Development of Decapod Crustacea," 'Phil. Trans.,' 1858, p. 602.

⁶ See article *Crustacea*, by Dr. Milne-Edwards, in Todd's 'Cyclopædia of Anatomy,' vol. i, 1836, p. 754.

these animals—a *head*, a *thorax*, and an *abdomen*; and from this custom we shall not depart, although we must avow that these denominations are only derived from very clumsy views, and are calculated to convey false impressions in regard to the nature and composition of the parts so named, by leading the mind to liken them to the grand divisions entitled head, thorax, and abdomen, in the Vertebrata.

“Nevertheless, with the exception of the objectionable names, the division of the body into three regions is not less a fact as regards the organization of the *Crustacea*; and the one and twenty rings of which, as we have said, their body consists in the type to which every member of the class may be referred, are generally found divided into three equal series of seven, each of which may be held as corresponding with one of the three regions.”

Dr. Dana, in his great work¹ on the *Crustacea*, distinguishes this class from the *Insecta* by its possessing a cephalothorax and an abdomen; the former having 14 segments, the latter 7.

The views of Mr. C. Spence Bate² and Mr. J. O. Westwood³ differ but little from those of Dr. Milne-Edwards. Mr. Spence Bate⁴ objects even more strongly to the use of the names ‘thorax’ and ‘abdomen,’ as applied to *Crustacea*, than Milne-Edwards, and recommends instead the terms ‘pereion’⁵ and ‘pleon,’⁶ as less calculated to mislead the student as to the homologies of the divisions of the body. But any names, however well devised, must fail to meet all the requirements of a class so diversified in its various orders as this. The frequent interblending of a part, or the whole, of the segments of the second division of the body with the head of the animal, necessitating a term like ‘cephalothorax’ to express it, has been the chief reason for their retention, and long usage must command a certain amount of respect even for a “clumsy” term.⁷

Prof. Huxley, in his lectures on the *Crustacea*,⁸ divides the body into 6 cephalic, 8 thoracic, and 6 abdominal segments or somites. He considers the caudal segment, or telson, not to be a segment, properly so called, but a peculiar median appendage; thus reducing them to 20 in all.

We give these several views on the adjoining page, and shall discuss their applicability as we proceed.

¹ ‘United States Expl. Exped. 1852, Crustacea,’ by J. D. Dana, vol. xiii, part i, p. 21.

² See ‘Brit. Assoc. Report,’ 1855, by Mr. C. Spence Bate, “On the British *Edriophthalma*,” p. 27.

³ C. Spence Bate and J. O. Westwood, on ‘British Sessile-eyed Crustacea,’ part i, p. 3, 1861.

⁴ C. Spence Bate, “On the Development of Decapod Crustacea,” ‘Phil. Trans.,’ 1858, p. 590.

⁵ From *περαιῶν*, to walk about.

⁶ From *πλέω*, to navigate.

⁷ The terms ‘head,’ ‘thorax,’ and ‘abdomen’ are still retained by Entomologists for the class *Insecta*, although some of the objections to their use in the *Crustacea* also hold good in that class.

⁸ “Lectures on the Crustacea,” by Prof. T. H. Huxley, F.R.S., ‘Medical Times and Gazette,’ 1857, p. 507.

(According to the

² "Crustacea have a cephalothorax, but not a head"—*Dana, on Homologies of Crustacea*.—'United States Explg. Expedition,' Crustacea, vol. xiii, p. 21, 1852.

BODY-RINGS OF THE CRUSTACEA, WITH THEIR APPENDAGES.

principal authorities.)

I. CEPHALON. (<i>C. Spence Bate</i>). ¹				I. CEPHALIC SOMITES (<i>Huxley</i>).			
I.	1.	Somite or Segment, bearing the Eyes.		I.	1.	Somite, bearing the Eyes.	
II.	2.	Ditto, bearing the 1st Antennæ.		II.	2.	„ „ „ Antennules.	
III.	3.	„ „ 2nd Antennæ.		III.	3.	„ „ „ Antennæ.	
IV.	4.	„ „ Mandibles.		IV.	4.	„ „ „ Mandibles.	
V.	5.	„ „ 1st Maxillæ, or 1st Siagonopoda.		V.	5.	„ „ „ 1st Maxillæ.	
VI.	6.	„ „ 2nd Maxillæ, or 2nd Siagonopoda.		VI.	6.	„ „ „ 2nd „	
II. PEREION.				II. THORACIC SOMITES.			
VII.	7.	„ „ Maxillipeds, or 3rd Siagonopoda.		VII.	1.	Somite, bearing 1st Maxillipeds.	
VIII.	1.	Bearing the 1st pair of appendages or Gnathopoda, or 4th Siagonopoda.		VIII.	2.	„ „ 2nd	
IX.	2.	The 2nd pair of appendages or Gnathopoda, or 5th Siagonopoda.		IX.	3.	„ „ 3rd „	
X.	3.	The 3rd pair of legs, or 1st Pereiopoda.		X.	4.	4th to 8th Somites, bearing Ambulatory legs.	
XI.	4.	„ 4th „ 2nd „		XI.	5.		
XII.	5.	„ 5th „ 3rd „		XII.	6.		
XIII.	6.	„ 6th „ 4th „		XIII.	7.		
XIV.	7.	„ 7th „ 5th „		XIV.	8.		
III. PLEON.				III. ABDOMEN.			
XV.	1.	1st Natatory legs or 1st Pleopoda.		XV.	1.	Each Somite furnished with a pair of appendages.	
XVI.	2.	2nd „ 2nd „		XVI.	2.		
XVII.	3.	3rd „ 3rd „		XVII.	3.		
XVIII.	4.	1st Caudal appendages, 4th „ or 1st Uropoda.		XVIII.	4.		
XIX.	5.	2nd „ 5th Pleopoda, or 2nd Uropoda.		XIX.	5.		
XX.	6.	3rd „ 6th Pleopoda, or 3rd Uropoda.		XX.	6.		
XXI.	7.	Telson, Terminal joint, or middle tail-piece.	(21. ²)			“Telson,” or median appendage, not furnished with any articulate limbs. ²	

¹ See Report on the "British Edriophthalma" ('British Assoc. Report' for 1855, by C. Spence Bate, when these terms were first introduced. See also 'History of British Sessile-eyed Crustacea,' by C. Spence Bate, F.L.S., and J. O. Westwood, M.A., F.L.S., Part i, p. 3. October, 1861. London: Van Voorst.

² "The last segment never bears true appendages, and is developed subsequently to the others from the dorsal surface of the body. Hence we are justified in regarding it, not as a somite, but as a peculiar median appendix to which the special name 'telson' [C. Spence Bate] may be applied."—See Prof. Huxley's Lectures, 'Medical Times and Gazette,' 1857.

We have seen that the generally accepted type-number of body-rings, or somites, is twenty-one; but in the fossil *Trilobita*,¹ and the recent *Phyllopoda* and *Branchiopoda*, we have instances in which a larger number of segments occur. On the other hand, we occasionally meet with forms, both recent and fossil, in which one or more segments are never developed; but in general their apparent absence is due to their coalescence, and we shall frequently find indications of this if we bear in mind the theory of Oken, that each pair of appendages indicate a separate segment.

In the illustrations of recent Crustacea which we have given on Plate IX we have numbered the somites of figs. 1, 2, 3, 4, and 5, so as to show at a glance how many segments are united to form the head in each, as indicated by the figure placed upon it.

The restored figures of *Pterygotus anglicus*, Ag., Plate VIII, are also similarly numbered.

"In the embryo these segments are formed in succession from before backwards, so that, when their evolution is checked, the later, rather than the earlier rings, are those that are wanting; and, in fact, it is generally easy to see in those specimens of full-grown crustaceous animals whose bodies present fewer than twenty-one segments that the anomaly depends on the absence of a certain number of the most posterior rings of the body."²

Just as we find a typical number of twenty-one body-segments to prevail among the Crustacea, so also in the appendages, the type number of joints is seven, any departure from which is disguised by fusion of one or more joints together, the obsolete condition of others, or the depauperization of the limb into numerous *articuli*. (C. Spence Bate.)

The walking leg of a Decapod Crustacean (see woodcut, fig. 1), or the maxillipede³ of *Pterygotus anglicus* (see woodcut, fig. 2), will serve as illustrations of limbs having the type-number of joints, which we will designate as follows:

<i>Coxa</i>	.	.	.	1
<i>Basos</i>	.	.	.	2
<i>Ischium</i>	.	.	.	3
<i>Meros</i>	.	.	.	4
<i>Carpus</i>	.	.	.	5
<i>Propodos</i>	.	.	.	6
<i>Dactylus</i>	.	.	.	7

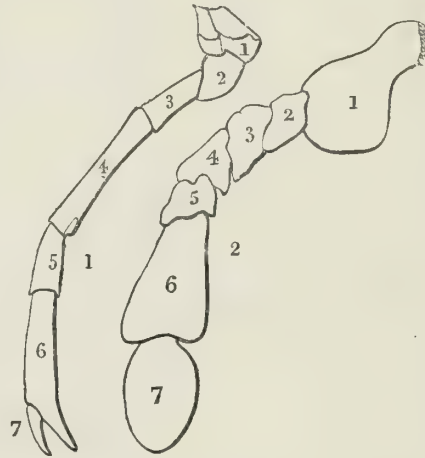


FIG. 1. Walking leg of Decapod. FIG. 2. Jaw-foot of *Pterygotus*.³

¹ See Mr. Salter's Monographs on the *Trilobita*, Pal. Soc., 1864-6.

² Milne-Edwards, 'Todd's Cycl. Anat.,' Article *Crustacea*, p. 753.

³ 'Ectognath' of Prof. Huxley, 'Geol. Surv.,' Mon. I, 1859, p. 19.

These terms, used by Mr. C. Spence Bate¹ for the several joints of the limbs of Crustacea, are merely abbreviations of Milne-Edwards's terms *coxopodite*, *basipodite*, &c., *coxognathite*, *basognathite*, &c. The appendage may be a *podoite*, or a *gnathite*; but it seems superfluous to repeat the term at every joint, especially in treating of the limbs of *Pterygotus*, which are gnathopodites, or jaw-feet.

The common Lobster and Prawn are very good typical forms; but it is impossible to offer in one view any general classification of the appendages of *Crustacea* which is suitable to the whole group; for the limbs, subservient to one purpose in the Decapod, fulfil a totally different function in the Stomapod or Branchiopod; or the segments themselves are so welded together in the one, and so separated in the other, as to require much careful examination in order to discover their homologies.

Indeed the only segment that may be said to be persistent, is that which supports the mandibles, for the eyes may be wanting, and the antennæ, though less liable to changes than the remaining appendages, are nevertheless subject to very extraordinary modifications, and have to perform functions equally various. Being essentially and typically organs of touch, hearing, and perhaps of smell, in the highest Decapods, they become converted into burrowing organs in the *Scyllaridæ*, organs of prehension in the *Merostomata*, swimming organs and claspers for the male in the *Cyclopoidea*, and organs of attachment in the *Cirripedia*.

Not to multiply instances, we have presented to us in the *Crustacea* probably the best zoological illustration of a class, constructed on a common type, retaining its general characteristics, but capable of endless modification of its parts so as to suit the extreme requirements of every separate species.

And it is doubtless in some degree due to this plasticity of structure, enabling the species to occupy such diverse positions, and to subsist upon such varied aliment, that the class owes its preservation through the lapse of ages represented by the long series of geological formations, from the very oldest Silurian strata to the present day.

It is interesting to review the long and laborious methods by which the fragmentary fossil remains of the ancient order of the *Eurypterida* have, by the labours of Agassiz, M'Coy, Hall, Huxley, Salter, and others, been made, after frequent readjustment, not only to fit together correctly, so as to furnish us with a notion of their living forms, but also to take their appropriate places in the class and order to which they belong.²

As I shall have frequent occasion to refer to the published labours of these gentlemen in the course of this Monograph, I will not further allude to them here.

The additional materials which have accumulated during the past eight years suffi-

¹ 'Phil. Trans.,' 1858, p. 604.

² See Messrs. Huxley and Salter's 'Monograph,' already quoted, pp. 1—11. See also article by the writer "On the Seraphim and its Allies," in the 'Intellectual Observer,' 1863, vol. iv, p. 229.

ciently explain the necessity for the commencement of a fresh Monograph, and I am happy to state, that, in undertaking it I have received the approval and kind assistance of my scientific colleagues, both in the British Museum and in the Museum of Practical Geology; and those gentlemen whose collections can best illustrate the work in hand have obligingly opened their museums for my use and reference. My warmest thanks are due to Prof. John Phillips, M.A., D.C.L., &c., and Mr. C. Spence Bate, F.R.S., &c., who, since the meeting of the British Association at Bath in 1864, have willingly aided me in my researches in the British Fossil Crustacea.

All assistance received will, I trust, be found duly acknowledged in its proper place.

The present part forms only the first chapter of the history of the *Merostomata*, but it has been considered desirable to issue this instalment on account of the number of plates needed to illustrate the entire group, and the consequent delay caused by their preparation.

CLASSIFICATION OF THE MEROSTOMATA.¹

I have experienced considerable difficulty in proposing a classification for this remarkable group that may appear to differ to any extent from the conclusions of the eminent zoologists who have preceded me in this work; but having the advantage not only of being able to consult and compare their published labours, but also of examining numerous specimens in a far better state of preservation than any hitherto examined or described in this country, I venture to hope that the following arrangement—with such modifications as may be deemed needful during the publication of the remaining parts of this Monograph—will be found to accord, not only with the general and detailed structure of the group and their family relationships, but also as an appropriately framed order of the great Crustacean class.

¹ This name (derived from *μηρός*, a thigh, and *στόμα*, a mouth) was proposed by Dr. J. D. Dana in his great work on the *Crustacea* (1852) already quoted, but is adopted here for a much larger group than was contemplated by him. I prefer to enlarge a group proposed by so eminent a carcinologist, to the alternative of introducing a fresh name or the adoption of one which, though older, is inappropriate, having been founded upon an incorrect view of the structure of the fossil forms it included. (See p. 24, paragraphs 28 and 33.)

Order—MEROSTOMATA, Dana, 1852.

Having the mouth furnished with mandibles and maxillæ, the terminations of which become walking or swimming feet and organs of prehension.

I. Sub-Order—EURYPTERIDA, Huxley, 1859.

Crustacea with numerous free thoracico-abdominal segments, the first and second (?) of which bear one or more broad lamellar appendages upon their ventral surface, the remaining segments being devoid of appendages; the anterior rings united into a carapace bearing a pair of larval eyes (*ocelli*) near the centre, and a pair of large marginal or subcentral eyes; the mouth furnished with a broad post-oral plate, or *metastoma*, and five pairs of moveable appendages, the posterior of which form great swimming feet; the telson, or terminal segment, extremely variable in form; the integument characteristically sculptured.

II. Sub-Order—XIPHOSURA, Gronovan, 1764.

Crustacea having the anterior segments welded together to form a broad, convex buckler, upon the dorsal surface of which the compound eyes and *ocelli* are placed, the former subcentrally, the latter in the centre in front; the mouth furnished with a small labrum, a rudimentary metastoma, and six pairs of moveable appendages. Posterior segments of the body more or less free, and bearing upon their ventral surfaces a series of broad lamellar appendages, the telson or terminal segment ensiform.

NOTE.—Having long been convinced of the propriety of expressing in some suitable manner the correctness of the conclusions of Professors Agassiz and James Hall as to the close affinity existing between the *Eurypterida* and the *Xiphosura*, and being fully persuaded at the same time that they naturally form two distinct, although closely related groups, I have ventured to unite them in the Order MEROSTOMATA—a name proposed by Dr. J. D. Dana for the recent King-crabs only, retaining at the same time the names *Eurypterida* and *Xiphosura*, as sub-orders; sufficient evidence for the correctness of which I trust to be able to bring forward before the completion of this Monograph.

Order—MEROSTOMATA, Dana, 1852.

I. Sub-Order—EURYPTERIDA, Huxley, 1859.

1. *Pterygotus*, Agassiz.
2. *Slimonia*, (*Page*) H. Woodw.
3. *Stylonurus*, (*Page*) H. Woodw.
4. *Eurypterus*, Dekay.
sub-genus *Dolichopterus*, Hall.
5. *Adelophthalmus*, Jordan,
6. *Bunodes*, Eichw.
7. *Arthropleura*, Jordan.
8. *Hemiaspis*, H. Woodw.
9. *Exapinurus*, Nieszk.
10. *Pseudoniscus*, Nieszk.

II. Sub-Order—XIPHOSURA, Gronovan, 1764.

1. *Belinurus*, (*König*) Bailly.
2. *Prestwichia*, gen. nov.
3. *Limulus*, Müller.

These thirteen genera contain about eighty-three species, which will be found in the accompanying Tables, with their geological position and locality, and also the geographical distribution of each genus as at present ascertained.

NOTE.—The divisions given in the following Tables for the Devonian strata must not be supposed to represent their absolute geological succession; they are only intended to show approximately the English and Scotch equivalents for those rocks which are considered to be of Lower, Middle, or Upper Devonian age. The succession of these beds is even now undergoing revision so as to render their correlation more consistent with those of the Rhine, Belgium, and France.

TABLE SHOWING THE GEOLOGICAL RANGE AND GEOGRAPHICAL DISTRIBUTION OF THE CRUSTACEA BELONGING TO THE ORDER MEROSTOMATA.

	AND UPPER SILURIAN.										DEVONIAN.												
	LOWER,			MIDDLE,			WENLOCK.				LUDLOW.			UPPER.			MIDDLE.			UPPER.			
	Llandello.	Upper.	Lower.	Llandovery.	Upper.	Lower.	Wenlock Shale.	Wenlock Limestone.	Lower Ludlow Shale.	Aymestry Limestone.	Upper Ludlow Beds (Micaceous grey sandstone).	Downton Sandstone and Passage-beds.	Sandstones of Forfarshire and Perthshire.	Bituminous Schists of Gamrie and Cathness.	Sandstones of Torquay.	Ilfracombe Beds, N. Devon.	Petherwyn Group, Cornwall.	Pilton Group, N. Devon.	Yellow Sandstone of Dura Den.				
I.																							
PALÆOZOIC CRUSTACEA																							
OF THE																							
ORDER																							
MEROSTOMATA, Dana.																							
I. SUB-ORDER																							
EURYPTERIDA, Huxley.																							
1. Genus—PTERYGOTUS, Ag.																							
<i>Pt. anglicus</i> , Agassiz.																							
" ———, (?)																							
" ———, (?) Eichwald.																							
" minor, H. Woodward																							
" ludensis, Salter																							
" problematicus, Salt.																							
" ———, (?)																							
" styllops, Salt.																							
" Banksii, Salt.																							
" gigas, Salt.																							
" perornatus, Salt.																							
" bilobus, Salt.																							
" arcuatus, Salt.																							
" Cobbi, Hall.																							
" macrophthalmus, Hall.																							
" Osborni, Hall.																							
2. Genus—SLIMONIA, Page.																							
<i>Sl. acuminata</i> , Salt, sp.																							
" <i>punctata</i> , Salt, sp.																							
" <i>scorpioides</i> , Salt, MS.																							
3. Genus—STYLONURUS, Page																							
<i>St. Powriei</i> , Page																							
" <i>Scoticus</i> , H. Woodw.																							
" <i>ensiformis</i> , H. Woodw.																							
" <i>Symondsii</i> , Salt, sp.																							
" <i>megalops</i> , Salt, sp.																							
" <i>spinipes</i> , Page (Logani, H. W.)																							

TABLE SHOWING THE GEOLOGICAL RANGE AND GEOGRAPHICAL DISTRIBUTION OF THE CRUSTACEA BELONGING TO THE ORDER MEROSTOMATA.
Continued.

II. PALÆOZOIC CRUSTACEA OF THE ORDER MEROSTOMATA, Dana.	UPPER SILURIAN.												DEVONIAN.												CARBONIFEROUS.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	Lower SILURIAN.						MIDDLE SILURIAN.						Wenlock.						Ludlow.						Lower.						Upper.						Lower.						Upper.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
	1, 2, 3			4, 5, 6			7		8		9		10		11		12		13		14		15		16		17		Middle.		21		22		23		24		25		26		27		28		29																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
	Woolhope Limestone and Denbighshire Grit.						Wenlock Shale.						Wenlock Limestone.						Lower Ludlow Shale.						Aymestry Limestone.						Upper Ludlow Beds (Micaceous grey sandstone).						Downton Sandstone and Passage-beds.						Sandstones and Slates of the Forest and Linton.						Lower Sandstones of Calhness.						Arbroath Paving-stones.						Sandstones of Forfarshire and Perthshire.						Middle.						Petherwyn Group, Cornwall.						Pilton Group, N. Devon.						Yellow Sandstone of Dura Den, &c.						Carboniferous Limestone of Scotland, alternating with Coal-bearing Sandstones.						Carboniferous Limestone of Ireland, Wales, and South of England.						Carboniferous Rocks, Ireland.						Millstone Grit.						Coal-measures, Colebrook Dale.						South Wales Coal-measures.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
4. Genus—EURYPTERUS, DeKay.</					

TABLE SHOWING THE GEOLOGICAL RANGE AND GEOGRAPHICAL DISTRIBUTION OF THE CRUSTACEA BELONGING TO THE ORDER MEROSTOMATA.
Continued.

III. PALÆOZOIC CRUSTACEA OF THE ORDER MEROSTOMATA, Dana. I. SUB-ORDER EURYPTERIDA, Huxley.	Lower SILURIAN.		Middle SILURIAN.		Upper SILURIAN.				DEVONIAN.				CARBONIFEROUS.											
	Lower.		Upper.		Lower.		Upper.		Lower.				Upper.											
	1, 2, 3.	4, 5, 6.	7	8	9	10	11	12	13	Sandstones and Slates of the Foreland and Linton.	Lower Sandstones of Caithness.	Arbroath Paving-stones.	Sandstones of Forfarshire and Perthshire.	Middle.	Petherwyn Group, Cornwall.	Pilton Group, N. Devon.	Yellow Sandstone of Dura Den.	Carboniferous Limestone of Scotland, alternating with Coal-bearing Sandstones.	Carboniferous Limestone of Ireland, Wales, and South of England.	Carboniferous Rocks, Ireland.	Millstone Grit.	Coal-measures, Colebrook Dale.	South-Wales Coal-measures.	
5. Genus — ADELOPHthalmus, Jordan. <i>Ad. granosus</i> , Jord.	Leintwardine Ditto	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
6. Genus — HEMIASPIS, H. Woodw. <i>H. limuloides</i> , Salt, MS. " <i>tuberculata</i> , Salt. " <i>optata</i> , Salt, MS. " <i>sperata</i> , Salt, MS. " <i>Salweyi</i> , Salt, MS. " <i>sp. nov.</i>
7. Genus — EXAPINURUS. <i>Ex. Schrenkii</i> , Nieszk.	Oesel	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8. Genus — PSEUDONISCUS, <i>Ps. aculeatus</i> , Nieszk.	Oesel	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9. Genus — BUNODES, Eichw. <i>B. lunula</i> , Eichw. " <i>rugosus</i> , Nieszk.	Oesel	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10. (?) ARTHROPLEURA, Jord. <i>Ar. armata</i> , Jordan " <i>ferax</i> , Salt. " <i>mammatus</i> , Salt.
II. SUB-ORDER. XIPHOSURA, Gronov.
1. Genus — BELINURUS, König. <i>B. trilobitoides</i> , Buckl. " <i>reginae</i> , Bailly " <i>arcuatus</i> , Bailly " <i>Danae</i> , Meek & Worthen

TABLE SHOWING THE GEOLOGICAL RANGE AND GEOGRAPHICAL DISTRIBUTION OF THE CRUSTACEA BELONGING TO THE ORDER MEROSTOMATA.

Continued.

IV. ORDER MEROSTOMATA, Dana. II. SUB-ORDER XIPHOSURA.	PRIMARY OR PALÆOZOIC.					SECONDARY OR MESOZOIC.					TERTIARY OR CAINOZOIC.					
	SILURIAN.	DEVONIAN.	CARBONIFEROUS.				PERMIAN.	TRIAS.	LIAS.	OOLITE.			CRETACEOUS.	TERTIARY.	RECENT.	
			24	28	29	30				Lower.	Middle.	Upper.				
2. Genus—PRESTWICHIA, gen. nov. <i>P. anthrax</i> , Prestw., sp. " <i>rotundata</i> , Prestw., sp.... Glasgow	... Cole- brook Dale Ditto	... ...	... ...	...	...	...	...	...	...	...	37	38	
3. Genus—? LIMULUS (Müll.) <i>L. ? oculatus</i> , Kutorga " sp. (Schimper) ... " ? ? <i>Steinla</i> , Geinitz	Ural Mountains Germany	...	...	...	...	...	...	...	...	...
LIMULUS, Müller. <i>L. gigas</i> , Münst. " <i>Walchi</i> , Desmar. " <i>ornatus</i> , Münst. " <i>intermedius</i> , Münst. " <i>brevispina</i> , Münst. " <i>brevicauda</i> , Münst. " <i>sulcatus</i> , Münst. " <i>Decheni</i> , Zincken	
LIMULUS, Müller. (Living Species.) " <i>Moluccanus</i> , Latr. " <i>rotundicauda</i> , Latr. " <i>longispina</i> , V. d. Hoev. " <i>polyphemus</i>

V. GENERA.	East Indies, and Japan.	North America.	Ireland.	England.	Scotland.	Baltic Isles.	Germany.	Poland.	Russia.	PALÆOZOIC.																NEOZOIC.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
										Upper Silurian.					Devonian.					Carboniferous.						Permian.	Triassic.	Oolitic.	Cretaceous.	Tertiary.	Recent.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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BIBLIOGRAPHY
OF THE
MEROSTOMATA;*

WITH AN ACCOUNT OF THE AFFINITIES PROPOUNDED BY THE
VARIOUS AUTHORS.

(For references see p. 20.)

1. 1809. Mr. W. MARTIN¹ gave a figure and short description of a Limuloid Crustacean from the Coal-measures, which he included with the *Trilobita*, and named *Entomolithus monoculites* ? (*lunatus*).

2. 1811. Mr. J. C. PARKINSON² figured a similar fossil from the Coal-measures, Dudley.

3. 1820. Mr. CHARLES KÖNIG³ figured a Coal-measure *Limulus*, naming it *Belinurus bellulus*, but there is no description accompanying it.

4. We find the first notice of the discovery of *Eurypterus* in America (in 1825), by Dr. J. E. DEKAY,⁴ who described and figured the only species then known (*Eurypterus remipes*), and referred it to the class CRUSTACEA, and to the order *Branchiopoda*.

5. The remains of an English species of *Eurypterus* (probably two feet in length) were described in 1831 by Dr. J. SCOULER,⁵ of Glasgow, under the generic name of *Eidothea*.

6. Dr. RICHARD HARLAN⁶ published the description of a second American species in 1835 (*E. lacustris*).

7. Prof. MILNE-EDWARDS,⁷ in 1834-36, observes, with respect to the genus *Eurypterus*, established by DekaY, "They have externally many points of resemblance to *Pontia* and *Cyclops*, and they also seem to indicate, in some respects, a passage between these animals and the *Isopoda*. The body is broad and more or less pyriform, and the head very distinct from the thorax, which is divided into many segments, but is not separated by any marked distinction from the abdomen. The head bears on its superior surface two reniform eyes, well developed, and distant from each other. Two pairs of antennæ have also been distinguished; and whatever other appendages there may be, appertain to the mouth. Lastly, on each side of the first thoracic ring one sees a great lamelliform swimming-foot, with a rounded termination."

"Geologists," M. Milne-Edwards adds, "describe three species of *Eurypterus*, viz., *E. remipes*, DekaY, *E. lacustris*, Harlan, and *E. Scouleri*, Hibbert."

* Should any omissions be discovered in this history, I shall feel obliged to palæontologists who will call my attention to them, that they may be inserted in the future parts of this Monograph.—H. W.

The *Eurypteridæ* are placed by Prof. Milne-Edwards at the end of the order *Cyproidea* or *Ostracoda*.

8. Dr. S. HIBBERT⁹ in 1836 referred the crustacean remains described by Dr. Scouler under the name *Eidothea* (§ 5) to the genus *Eurypterus*, with the specific name of *Scouleri*.

9. The Rev. Dr. BUCKLAND,¹⁰ in 1836, described a fossil *Limulus* from Coalbrook Dale, under the name of *L. trilobitoides*.

10. In 1838 Dr. S. KUTORGA¹¹ described and figured a head-shield of *Limulus* from the Permian formation of the western slopes of the Ural Mountains (Government of Perm), under the name of *L. oculatus*.

11. In 1838 Prof. MILNE-EDWARDS¹² took the opportunity to examine the eggs of *Limulus* containing the young ones about to be hatched; he found that at this stage of their development they present very little difference in the conformation of the anterior portion of their body from that which exists in the adult; but the abdominal portion of the body bears only three pairs of appendages, and the long styliform tail (telson), so remarkable in the adult, does not exist at all; the form of the abdominal portion likewise is equally different at this epoch.

12. M. J. VAN DER HOEVEN,¹³ in 1838, gave an anatomical description of *Limulus*, and described four living and six fossil (Oolitic) species; the latter are all from Solenhofen.

13. M. G. FISCHER DE WALDHEIM¹⁵ described a new species of *Eurypterus* from Russian Podolia, under the name of *E. tetragonophthalmus*, in 1839.

14. In 1840 Mr. J. PRESTWICH¹⁶ described and figured two new species of fossil *Limuli*, *L. anthrax* and *L. rotundatus*, from the clay-ironstone of Colebrook Dale Coal-field.

15. In 1840 Count MÜNSTER¹⁷ figured and described a fragment of a very large *Limulus* from the Solenhofen Slate of Bavaria, naming it *Limulus giganteus*.

16. In 1841 MÜNSTER¹⁸ described and figured an imperfect specimen under the name of *Limulus priscus*, which has since been referred by H. von Meyer to his genus *Halicyna*. The specimen is from the Muschelkalk of Wurtemberg.

17. In 1841 Mr. CONRAD,¹⁹ in New York, notices a single American specimen of *Eurypterus* (*E. remipes*), which he says when perfect had a long spiniform tail, like *Limulus*, but more obtuse and finely serrated.

18. In 1843 Mr. VANUXEN²⁰ figured a head and first articulation of *E. remipes*, but added no new facts.

19. In the same year General PORTLOCK²¹ figures a specimen said to be from the Carboniferous Shale ("most probably, however, Coal-measures," *Baily*), Maghera, County Derry, doubtfully referred to *L. trilobitoides*.

20. Some fragments of a fossil—supposed at the time to be parts of fishes—were figured by Prof. L. AGASSIZ²² (1844), from the Old Red Sandstone of Forfarshire. "Deceived by the scaly aspect of a portion of the carapace, I at first," says Prof. Agassiz,

"believed that this might be the type of a peculiar genus of fishes, and to that class I referred *Pterygotus* in my enumeration of the fossil fishes of the Silurian system, published in Murchison's great work"¹⁴ (1839). The discovery of more perfect remains in Scotland convinced Agassiz that they must be Crustacea. He adds, "I am rather inclined to believe that this singular animal will become the type of a family intermediate between the *Trilobites* and the *Entomostraca*, in which, perhaps, the *Eurypteri* and the *Eidotheæ* will some day be included."

21. 1845. THE REV. P. B. BRODIE, M.A., F.G.S.,²³ in his 'History of Fossil Insects,' describes and figures a curious fossil in clay-ironstone from Coalbrook-dale resembling the Caterpillar of the Emperor Moth (*Saturnia pavonia-minor*). This has since been described (1863) by Mr. J. W. Salter, as *Eurypterus* (*Arthropleura*) *ferox*.

22. Dr. H. BURMEISTER,²⁴ in his systematic arrangement of Trilobites, &c. (1846), makes the *Eurypteridæ* the first family of the tribe *Palæadæ*, which, he observes, are "characterised by the possession of two large compound eyes, by the absence of secondary eyes, and by having short undeveloped feelers and soft leaf-formed feet, bearing gills," &c. Of the *Eurypteridæ* he says, "In these there is no shell. The head, whose position is very distinct, bears two pairs of setaceous feelers and one pair of accessory parts of the mouth. There are probably nine (?) rings in the thorax, the first of which bears a pair of very large rudder-shaped feet, furnished with five joints, and the succeeding rings seem to have borne similar leaf-like feet of an equal size. The abdomen consisted of three or six rings, and was terminated by a pair of rudder-fins (?)."

23. 1847. HUGH MILLER²⁵ gives an interesting description of Agassiz's first examination of the remains of *Pterygotus* in Mr. Webster's collection from Balruddery; and he figures a portion of a foot-jaw (supposed at that time to be a tail-lobe).

24. In 1850 Dr. H. B. GEINITZ²⁶ figures and describes a fossil remain from the Chalk formation (Lower Pläner) of Plauen in Saxony, which he names *Limulus Steinlæ*. Not having seen the original specimen, we should hesitate to deny its crustacean character; but we see no evidence of its affinity to *Limulus*, judging from the figure given.

25. Dr. FERDINAND ROEMER,²⁹ in 1851, gave a notice of *Eurypterus*, in which he suggested the affinity of that genus with *Limulus*; pointing out, however, the great difference in the feet, &c.

26. Mr. J. W. SALTER,³⁰ in 1852, figured and described two fragments of the chelate appendages of *Pterygotus problematicus*, Agassiz, from the Upper Ludlow Rock, Herefordshire.

27. M. ED. VON EICHWALD,³¹ in 1854, gives figures of *Eurypterus tetragonophthalmus* of Fischer, which—as Mr. James Hall has pointed out—he erroneously ascribes to *E. remipes* of Dekay. He also figures a perfect segment of *Pterygotus*, which he ascribes to *Pt. Anglicus*, Ag. He considers that *Eurypterus* and *Pterygotus* were very closely allied genera. M. von Eichwald's specimens are from the Island of Œsel, in the Baltic.

28. Prof. F. M'Coy, in 1849,²⁶ and again in 1854,³³ thus classifies this group—"Ord. Entomostraca, Trib. *Pæcilopoda*. This group being distinguished from other Entomostraca by having crustaceous, didactyle, ambulatory, thoracic feet, as well as membranous, respiratory, abdominal ones, is, I think, clearly the place for those remarkable genera *Eurypterus* and *Pterygotus*." He adds further, "The tribe *Pæcilopoda* might be resolved into two families—1st, *Limulidæ*—*Limulus*; 2nd, *Eurypteridæ*—*Eurypterus*, *Pterygotus*, *Bellinurus*."

29. Prof. M'Coy³⁵ also figures and describes the head of *Eurypterus cephalaspis*, from Kendal (Pl. I E, fig. 21), a somewhat doubtful form. His *Pterygotus leptodactylus* is founded on the tail-spines of *Ceratiocaris*, as pointed out by Mr. Salter.

Like Dr. Hibbert,⁹ he attributes to Dr. Harlan (1835) the genus *Eurypterus*, which was established by Dr. J. E. Dekay⁴ in 1825.

30. Prof. F. J. PICTET³⁴ (1854) places *Eurypterus* with the *Copepoda*, adopting Burmeister's²⁴ description. In the *Xiphosura* he places *Limulus*, *Halycine*, *Bellinurus*, and *Pterygotus*.

31. In Prof. OWEN's 'Lectures'³⁶ (1855) we find the order *Xiphosura* placed in the sub-class *Entomostraca*, along with the orders *Trilobita* and *Phyllopoda*.

32. Prof. A. E. REUSS,³⁷ in 1855, gives a description of what he considers to be a new genus of Eurypterids, from the Coal Shale of Bohemia, preserved in the Prague Museum. He names it *Lepidoderma Imhoffi*, but it is certainly a *Eurypterus*, judging, not only from his beautiful plates, but also from a cast sent to us by Dr. Anton Fritsch.

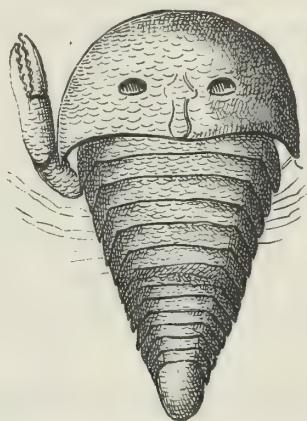


FIG. 3. *Pterygotus problematicus*, Agassiz [copied from Prof. M'Coy's figure in Lyell's 'Manual of Geology,' 1855 (5th edition).]

33. Prof. M'Coy again, in 1855,³⁵ furnishes us with a classification and descriptions of species of this group; and in SIR CHARLES LYELL's Manual³⁸ he gives a restoration of *Pterygotus problematicus*, where he again expresses his belief in the close alliance of *Pterygotus* and *Eurypterus*, and of both these to the living King-crab, or *Limulus*.

34. In the same year Mr. DAVID PAGE³⁹ named various species, and offered a restoration of *Pterygotus*. He observed that "The *Pterygotus* could be classed with no

living family, and was in aspect more like the larvæ than the adult forms of any Crustacean with which we are acquainted."

35. Later in the same year Sir R. I. MURCHISON⁴⁰ gave an account of the discovery, by Mr. Robert Slimon, of a remarkable series of Pterygotian remains at Lesmahago; Lanarkshire, in which he observes that the uppermost Silurian Strata in Russia, in England, and in North America, are characterised by the presence of *Pterygotus* and *Eurypterus*, associated with small *Lingulæ* and other fossils.

36. 1856. Mr. J. W. SALTER⁴¹ follows with a description and figures of a new genus of *Pterygoti*, viz. *Himantopterus*, of which he there gives notice of six species, namely, *H. maximus* and *acuminatus* (now united in *Slimonia acuminata*), *H. bilobus*, *H. perornatus*, *H. Banksii* (now referred to *Pterygotus*) and *H. lanceolatus* (since referred to *Eurypterus*).

37. 1856. Prof. T. H. HUXLEY⁴² adds some observations on the structure and affinities of *Himantopterus*. The conclusion he draws is that "The nearest approach to *Himantopterus* which could be constructed out of the elements afforded by existing Crustacea would be produced by superinducing, upon the general form of a Cumoid Crustacean, such a modification of the appendages as we find among the Zoæform Macruran larvæ." In fact, that *Himantopterus* bears a strong similarity to a larval form, but is not itself therefore to be considered embryonic.

38. In 1856 Dr. H. JORDAN and HERMANN VON MEYER⁴³ described a curious (blind) Crustacean from the Culm-formation of Saarbruck under the name of *Adelophthalmus* (*Eurypterus*) *granosus*, Jord.; also the fragment of a second remarkable form which is named *Arthropleura armata*, Jord.

39. 1856. Mr. DAVID PAGE⁴⁵ gives figures of *Pterygotus*, *Himantopterus*, *Stylonurus*, and *Slimonia*, and observes, "Respecting these Crustaceans, their place is altogether unknown in zoology, there being, as it were, an interfusion of phyllopod, pœcilopod, and decapod,—of brachyurous, macrourous, and xiphosurous forms."

40. In Prof. T. H. HUXLEY'S⁴⁶ 'Lectures on Natural History,' published November 7th, 1857, appears the following description of the *Eurypterida*:—"This group includes the Devonian and Silurian genera *Eurypterus* and *Pterygotus*, which, though as little embryonic in their characters as the *Trilobita*, are, in many respects, curiously larval. These singular Crustaceans attained a very great size, species of *Pterygotus* of several feet in length being known. The body, in those forms which have been most carefully examined, consists of a comparatively small carapace, rounded anteriorly, and carrying on its upper surface a pair of elevations, which are distant in *Pterygotus* and approximate in *Eurypterus*, and were, in all probability, the eyes.

"Ten to twelve distinct segments succeed the carapace, becoming narrower posteriorly to the last, varying in shape from lanceolate to oval, and deeply emarginate, probably represented a telson.

"Three pairs of appendages were attached to the carapace in *Pterygotus*—anterior pincer-like antennæ; median toothed mandibles, provided with a large palp; and a pair

of posterior long gnathites, with a large toothed coxopodite, succeeded by a number of joints, the last of which has the form of an oval palette. These last members probably performed the function of locomotive or swimming feet. A considerable epistomial region lies in front of the mouth, as in *Limulus*, and a large oval plate, emarginate anteriorly, covered the mouth in the median line.

“No limbs have been found in connection with the abdominal somites, nor have any detached parts different from those just described been as yet discovered. Many parts of the surface of the body and of the appendages exhibit an exceedingly peculiar structure, resembling the conventional representation of feathers, or the mode in which they are represented in the Assyrian and Egyptian sculptures; and it was from this cause, apparently, that the Scotch quarrymen conferred the title of ‘Seraphim’ upon the *Pterygotus*.

“The *Diastylidæ* are the only *Crustacea* with which I am acquainted which exhibit anything similar to this ornamentation; and in the number of free somites, and the more or less rudimentary condition of the abdominal appendages, this aberrant group of *Podophthalmia* presents other analogies with the *Eurypterida*. The carapace, the prehensile antennæ, the largely developed posterior gnathites of *Pterygotus*, are to be paralleled among the *Copepoda* and *Xiphosura*, from which, however, and indeed from all other adult *Crustacea* with which I am acquainted, the *Eurypterida* differ widely in certain other respects.

“The absence of developed posterior thoracic and abdominal members in a Crustacean possessing the corresponding somites is to be met with, in fact, only among the Zoëiform larvæ of the *Macrura* and *Brachyura*, in which, as we have seen, the proportions of the body are not dissimilar to those of the *Eurypterida*, where the abdominal appendages are entirely absent, and the well-developed and conspicuous thoracic and cephalic members are not more than two or three pairs in number, and consist of antennæ and maxillipedes, the latter serving as locomotive organs.

“I conceive, therefore, that the *Eurypterida* must form a group by themselves, which are best understood by combining together organic peculiarities at present found only in the *Copepoda*, the *Xiphosura*, the *Diastylidæ*, and the larvæ of *Podophthalmia*.”

41. In June, 1858,⁴⁷ Mr. J. W. SALTER communicated to the Geological Society descriptions and figures of six new species of *Eurypterus*, and gave an account of the distribution of the group.

42. On the 22nd January, 1859,⁴⁸ appeared Messrs. HUXLEY and SALTER’s grand Monograph ‘On the Anatomy and Affinities of the Genus *Pterygotus*,’ with descriptions of twelve species (pp. 105, 8vo, and sixteen folio plates).*

43. In the same year a Russian naturalist, Dr. JOHANNES NIESZKOWSKI,† published

* This standard work will necessarily be so frequently referred to in the pages of this Monograph, that it would be superfluous to give a mere extract from it here. Its authors are quoted in clauses 26, 36, 37, 40, 41, 45, 51, and 57.

† Dr. Nieszkowski’s paper is referred to by Mr. Salter, ‘Quart. Journ. Geol. Soc.,’ 1863, vol. xix, p. 81; but the author’s name is misprinted Wieszkowski.

a paper, which he had read in October, 1858, to the Dorpat Naturalists' Society⁴⁹ on *Eurypterus remipes* from the Upper Silurian strata of the Island of Oesel, Baltic. Dr. Nieszkowski gives restorations of the upper and under sides of *Eurypterus*; and in the latter figure he shows the appendages of the mouth *in situ*, and three thoracic plates for the under side of the body. We think this possibly arises from a misconception of the median appendage, but shall refer to this paper again when treating of the genus *Eurypterus*.

44. In a second paper communicated to this society, in October, 1858, Dr. NIESZKOWSKI⁵⁰ describes and figures *Bunodes lunula* of Eichwald, and a new species, which he names *B. rugosus*; also two new genera allied to *Hemiaspis*, namely, *Exapinurus Schrenkii*, and *Pseudoniscus aculeatus*; all these are from the Upper Silurian of Rootziküll, Island of Oesel, Baltic. He has likewise figured a metastoma or lip-plate of *Pterygotus*, four inches in length and three inches broad, from the same locality.



FIG 4. *Pterygotus anglicus*, Agassiz, restored (1859).

45. The third (second) edition⁵¹ of Sir R. I. MURCHISON'S 'Siluria' (1859) furnishes us (besides numerous separate notices of the *Eurypterida*) with a restored figure, by Mr. J. W. Salter, of *Pterygotus anglicus*, about one twentieth natural size, giving all the details then known.

46. Mr. DAVID PAGE⁵² gives us (1859) restorations of *Pterygotus anglicus*, *Himantopterus acuminatus*, *Stylonurus Powriei*, *Stylonurus spinipes*, *Eurypterus clavipes*, *Euryp-*

terus Scouleri, and *Limulus rotundatus*, all more or less correct. He repeats most of his former views, and makes some critical remarks upon Mr. Salter's restoration, as given in 'Siluria,' which, however, he reproduces.

47. At the close of 1859 Prof. JAMES HALL,⁵³ Geologist for the State of New York, in his 'Report on the Palæontology of New York,' gives a very excellent account of *Eurypterus*, with many figures of the actual fossils and restorations of the genus, also figures of the more rare American species of *Pterygoti*. Frequent reference will be made to Prof. Hall's work in the course of this Monograph.

48. Mr. W. H. BAILY⁵⁴ describes (1859) some new forms of *Limuli* from the Coal-measures, for which he proposes the names *Belinurus reginæ* and *B. arcuatus*; they were found in the Bilboa Colliery, Queen's County, Ireland.

49. In 1862 Mr. C. GIEBEL⁵⁵ describes a *Limulus*, which he names *L. Decheni*, from the Braunkohlen-Sandstein near Teuchern, Prov. Saxony.

50. 1862. Prof. JAMES HALL⁵⁶ figures the carapace of what may possibly be, as he suggests, the shield of a *Limulus*-like Crustacean in the Potsdam Sandstone, Black River, Wisconsin. It has, however, somewhat more the aspect of a crushed Trilobite shield than the head of a *Limulus*.

51. In May, 1862, Mr. J. W. SALTER communicated to the Geological Society of London⁵⁷ descriptions and figures of some species of *Eurypterus* and allied forms, and he there makes the following remarks upon *Pterygotus*, &c.:

"Since the appearance, in 1859, of the Memoir by Prof. Huxley and myself on *Pterygotus* and its allies, the great work of Prof. Hall, of Albany, has appeared ('Palæontology of New York,' vol. iii), containing the fullest material for the illustration of this genus; and following, as it did, upon the very full account given by Dr. Wieskowski,* it has completed our knowledge of the structure of this remarkable genus. And there seems to be now no doubt whatever that the anomalous plates and processes,† about the position of which Prof. Huxley and myself were compelled to guess, and which for many obvious reasons were compared with the under portion of the head, really belong to the under part of the thorax. All this was as satisfactorily made out by the Russian author as by Prof. Hall's independent researches. We had also arrived at the same conclusion before Wieskowski's* admirable paper reached us. For, previous to the Meeting of the British Association at Aberdeen, in 1859, I was sent by the Director-General of the Geological Survey to examine the collections made by Mr. Slimon, of Lesmahago; and in that fine series (which was sent to the Meeting for exhibition) we found abundant proofs of the true position of the sternal plates, such as Wieskowski* and Hall have figured, and of the place of the post-oral plate, previously assigned by Prof. Huxley to the hinder margin of the mouth. The position of the chelæ in these new specimens also confirmed the Professor's

* For Wieskowski read Nieszkowski. See Ante, p. 26, ¶ 43.

† The thoracic plate, or operculum.

judgment in assigning them to the antennæ or antennules; and they supported my own view, too, as to the existence of three pairs of appendages to the head, exclusive of the chelæ and the large swimming-feet, which are also, as we learn from the new and more perfect specimens found, both in America and Russia, included with the appendages of the mouth.

“The chief new points, I take it, in Prof. Hall’s beautiful series are, first, the larger number of joints in the great maxillary appendages than was supposed from analogy with *Pterygotus*, where there are certainly only seven; and, secondly, the existence of ocelli on the dorsal surface of the shield, such as give it a wonderfully Limuloid aspect. But some of the *Copepoda* have similar ocelli; and as to the affinities, it would be out of place in every way to give my opinions when the naturalist is by who first truly studied these relations. Whatever corrections better specimens may have led to, the main credit is due to him who from fragmentary materials constructed a true hypothesis.”

Mr. Salter describes⁵⁷ *E. pulicaris* from the Devonian of St. John’s, New Brunswick; a fragment of a species allied to *E. Scouleri*, from the Coal-measures, Port Hood, Cape Breton; part of the telson of a *Eurypterus* (?) from Coal-measures, Nova Scotia.

He also gives⁵⁷ a fresh description (without a figure) of *E. Scouleri*, Hibbert, and figures and describes *E. (Arthropleura?) mammatus* and *E. (Arthropleura) ferox*, the first from Kirkton, Bathgate; the second from Pendleton Colliery, near Manchester; the third from the (Penny-stone?) Ironstone, Coal-measures, North Staffordshire.

52. 1863. Mr. W. H. BAILY⁵⁸ gives a more complete account of the new *Limuli* from the Irish Coal-measures, and good figures of *Belinurus reginæ* and *B. arcuatus*.

53. In November, 1863,⁵⁹ a notice appeared by the author, with figures, of *Slimonia (Pterygotus) acuminata*, in which he showed the propriety of placing this species in a distinct genus (as proposed by Mr. David Page), and pointed out many important characters by which it is at once separable from *Pterygotus*.

54. In 1864 the author described and figured⁶⁰ *Eurypterus lanceolatus*, Salter, from Lanarkshire, only imperfectly known before.

55. In the same year he exhibited specimens and restored figures of *Stylonurus*, *Pterygotus*, *Slimonia*, *Eurypterus*, and *Hemiaspis*, before the British Association,⁶³ Bath; and in November he published⁶¹ descriptions and figures of *Stylonurus Logani*, *Styl. ensiformis*, *Eurypterus Brewsteri*, and *Pterygotus minor*, and likewise gave a list of all the then known British species, with localities.⁶¹

56. In 1865 Sir CHARLES LYELL⁶⁴ published an amended figure of *Pterygotus Anglicus*, to supersede that which had been designed by Prof. M’Coy.

57. In November of the same year the Geological Society⁶⁵ published the author’s descriptions of *Stylonurus Scoticus* and *Stylonurus Powriei* from the Devonian of Forfarshire, and *Hemiaspis limuloides* from the Lower Ludlow Rock, Leintwardine.

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Order—MEROSTOMATA, *Dana*.Sub-Order—EURYPTERIDA, *Huxley*.Genus 1.—PTERYGOTUS, *Agassiz*, 1844.

ALTHOUGH *Eurypterus* was the first-discovered genus of this sub-order, both in this country and also in America, as we have seen by the foregoing history, I have nevertheless preferred to commence this Monograph with the genus *Pterygotus*, as having become historically the most important in England; its affinities having been studied and its structure described by such distinguished naturalists and palæontologists as Messrs. Agassiz, McCoy, Salter, Huxley, and Hall.

The genus *Pterygotus* not only contains the largest species of the whole order, and probably of the whole Crustacean class, but the remains of several of the species are exceedingly perfect and complete. Even the great *Pterygotus anglicus*, which forms the subject of this chapter, once only known by a few gigantic fragments, is now capable of restoration from almost entire specimens figured in the accompanying plates.

For the discovery and preservation of these very perfect remains we are indebted to the accurate geological knowledge and untiring exertions of Mr. James Powrie, F.G.S., of Reswallie, Forfar, who during many years has not only encouraged the quarrymen to preserve the organic remains from the “Arbroath paving-stone” and overlying shales, but has also personally worked in the quarries of the district for days and weeks together to procure specimens.

No higher testimony can be afforded as to the value of my friend's labours than by referring to the accompanying plates, the materials for which were nearly all furnished by his own museum, those figured from the British Museum having likewise been procured and presented by him.

The great “Seraphim” of the Scotch quarrymen, *Pterygotus anglicus* of Agassiz,¹ was the first species described² (1844), and is now very well represented, not only in detail, by numerous detached organs and parts of bodies, but also by four nearly entire bodies of various sizes.

¹ See Bibliography, p. 22, ¶ 20.

² In Murchison's ‘Silurian System’ (1839), p. 606, pl. iv, figs. 4 and 5, two fragments of *Pterygotus* are figured and described by Prof. Agassiz under the name of *Sphagodus pristodontus*; these have since been referred by Mr. Salter (Mem. Geol. Survey, Mon. I, p. 89) to *P. problematicus*, Ag.

The largest of these measures about four feet in length and some fifteen inches in breadth,¹ and is preserved in the Arbroath Museum, having been presented to that institution by Lord Dalhousie. It was obtained from his lordship's quarries at Carmyllie, in Forfarshire.

The specimen is preserved as an intaglio upon a large slab of Devonian sandstone, into which the detached body fits, as into a mould, exhibiting both the upper and under surfaces of eight of the body-segments united together. The head is wanting, but a portion of the base of a foot-jaw (maxillipede) belonging to the right side remains; the operculum or thoracic plate is also partially preserved.

The next largest example is from the Turin Hill Quarries, Forfarshire, and was presented to the British Museum by James Powrie, Esq., F.G.S. It is but very slightly distorted, and exhibits the natural rounded form of the dorsal surface of the body in an admirable manner. Ten of the body-rings are preserved united, measuring twenty-seven inches in length by about ten inches across the widest segment.

The third, which is figured on Pl. I, fig. 1, is twenty-three inches in length and seven inches in its greatest breadth; it was obtained from the same locality as the one last before mentioned. In this specimen the ventral surface is exposed to view, exhibiting the metastoma or post-oral plate (*p*), preserved upon the slab nearly in its normal position, with a portion of the left maxillipede by its side, suggesting the probability of the head being also concealed in the matrix beneath. The operculum, or thoracic plate (*o*), with its central lobe (*c*), is seen *in situ* overlying the first and second body-segments. The trunk is nearly entire, and only slightly compressed along the right side. The telson (*t*) is detached from the last segment. These three specimens are destitute of heads and appendages (save the two median appendages mentioned), but they serve well to illustrate the general form of the body at three different periods of growth. The first and largest would, if restored, represent an individual about five feet in length; the second one about three feet six inches; and the third about two feet. They are all from the "Arbroath paving-stone." The fourth, and smallest, but by far the most perfect specimen hitherto met with, was obtained by Mr. Powrie from the indurated shale overlying the "Arbroath paving-stone." From this shale, which is very finely laminated, and breaks up throughout into cuboidal fragments, Mr. Powrie has also obtained many new and interesting species of Fishes.²

The specimen is figured of the natural size at Plate II, fig. 1, and, although the dorsal surface is exposed, the whole animal has been so flattened out and compressed that some of the organs of the mouth are seen, as faint impressions, through the integument of the

¹ It was probably considerably broader, as one side is very much plicated along the margin for almost the entire length of the body.

² See Mr. Powrie's valuable paper upon the geology of this district, with descriptions of the Fish Remains, &c., discovered by the author, 'Quart. Journ. Geol. Soc.,' 1861, vol. xvii, p. 534.

head, whilst the remainder are displaced so as to be exposed upon the surface of the shale immediately in front of it.

One of the antennæ (*c*) is well seen, with its large denticulated chela, but only the three distal articulations can be discerned. Three gnathites, or jaws, are seen upon the right side of the head, and five on the left; there is little doubt that the two gnathites, marked 1, 1, in the figure, although now on opposite sides, both belonged to the right side; also one of the detached seven or eight jointed palpi of the gnathites (probably the third from the front) on the left side belonged to the right. Figures 1, of the right series, and 2 and 3 of the left side, show the gnathites with their palpi attached. The great swimming-foot, or maxillipede (5), on the right side, has been twisted round the wrong way, and lies with its inner margin turned outwards. The gnathite marked 4, on the right side, probably belonged to it. That on the left side is but little displaced, and exhibits the gnathite (5) with its broad rowing appendage still attached.

The swimming-feet of this specimen exhibit at *i, i*, a small, somewhat triangular plate, united to the border of the penultimate joint, and overlapping the oval terminal palette. This has not been observed before in *Pterygotus anglicus*, but I had already detected it in *P. perornatus*, *P. bilobus*, *Slimonia acuminata*, and *Eurypterus lanceolatus*; and it is figured by Prof. James Hall in his history of the American species of *Eurypterus*.¹

The impress of the large heart-shaped metastoma, or post-oral plate (*m*), can clearly be discerned in the centre of the head, and the large oval marginal eyes (*o, o*) are also to be observed on the anterior border. Even the outline of the thoracic plate, or operculum, is seen beneath the first and second segments of the body.

The immature condition of this specimen is indicated, not only by its comparatively small size (eleven inches in length), but also by the extreme thinness of its integument, the whole body being folded or crumpled obliquely across the fourth, fifth, and sixth somites, and also across the telson or terminal joint. The indications of a central ridge upon the three last abdominal segments is but very slight as compared with the same segments in more adult individuals. The telson is much narrower in proportion to its length, as compared with the large example figured on Plate VI, whilst its extremely thin but prominent central ridge is folded down towards the right side of the median line, leaving only a faint mark upon its surface.

On Plate I, fig. 4, is represented a minute but almost perfect specimen, named *Pterygotus minor* (see Geol. Mag., vol. i, p. 199, pl. x, fig. 2), from the same indurated shale as the above example, and in a precisely similar state of preservation. The eyes in *P. minor* are more within the margin of the head than in the larger specimen (Plate II, fig. 1), but we should not place implicit reliance upon this character, as, no doubt, in the earliest stage the eyes closely approximated.

Detached portions and appendages of Pterygotus anglicus.—Although for the purpose

¹ 'Nat. Hist. New York,' "Palæontology," vol. iii, 1859, pp. 397 and 400

of obtaining a correct idea of the general form of the body and the position of the appendages, entire specimens, such as the foregoing, are invaluable, we must not, therefore, omit to study carefully the far more numerous detached portions which have been met with, and the separate parts of appendages, as they not unfrequently offer details less clearly seen in the more perfect remains.

We have only to turn over the first seven plates, and especially to note the beautiful series of appendages figured in Plate VII,¹ to be convinced of their great value, not only in enabling us to complete our knowledge of the anatomy of these very ancient Crustacea, but also accurately to ascertain their proportions.

The Carapace.—At the period of the publication of Messrs. Huxley and Salter's Monograph the only examples of the carapace of this genus were in the collection of Lady Kinnaird.² One of these curious flattened plates is figured at plate iii, fig. 1, of that work, which led to the conclusion that the head-shield was trapezoidal in form when perfect (op. cit., p. 11); but the tolerably perfect detached head figured on Plate I, fig. 2, shows a decidedly semicircular front, as is also well seen in the head of the nearly entire but smaller specimen (Plate II, fig. 1), in which the posterior angles are also considerably rounded off where the carapace is united to the thoracic somites.

The organs of the Head.—In speaking of the paired appendages of the cephalon, we shall observe the same order as is given for the restored figures of *Pterygotus anglicus*, in the explanation of figs. 1, and 2, Plate VIII.

The Eyes.—Both the detached head on Plate I, fig. 2, and that on Plate II, fig. 1, exhibit the large convex marginal eyes upon the antero-lateral border of the carapace; but I am unable, in these or in any of the other specimens which I have examined, to detect the faceted surface of the cornea. Mr. Salter, however, has satisfactorily made them out in the specimen from Lady Kinnaird's cabinet, and says (Mon. cit., p. 68.)—"The lenses are rather large, about eight rows in one tenth of an inch, and in this specimen are rhomboidal rather than hexagonal, at least in arrangement; this may be due to pressure only." (See 'Survey Mon.,' pl. iii, fig. 1, 1*a*, and 1*b*.) Prof. Huxley observes (op. cit., p. 20)—"Notwithstanding the peculiar character of the markings upon the corneal surfaces of these eyes, I wait for better evidence than I have hitherto met with, before deciding that they were really compound, and that these markings indicate corneal facets."

No ornamentation can be detected on the head-shield of the smaller specimen (Plate II, fig. 1), but the surface of the larger detached carapace (Plate I, fig. 2), when magnified,

¹ Copied (with the exception of fig. 4) from plates vi and vii of Messrs. Huxley and Salter's Monograph on the *Eurypterida* (1859), from Mr. C. R. Bone's very excellent figures.

² Although these and other specimens are spoken of in the 'Survey Monograph' as "from the collection of Lord Kinnaird," I am informed by my friend Mr. Powrie that it is her ladyship who is especially devoted to palæontology; and I therefore beg leave to associate her name with these interesting specimens in the collection of which she has taken so much interest.

presents a finely punctated appearance, as represented in Plate I, fig. 2*a*, but there is no appearance of any scale-like markings upon it, as upon the appendages and somites.

The chelate Antennæ.—The very fine examples of these organs drawn on Plate VII, figs. 1—3, from specimens in the museum of Lady Kinnaird, Rossie Priory, Perthshire, and the Watt Institution, Dundee, still remain unrivalled. Three joints at least may be observed in this member. “The first is an elongated subcylindrical stem, flattened by pressure,” in fig. 2, but retaining its normal rounded form in fig. 4; “the next, short, enlarged, and swollen, is produced into a long slender process, pointed and incurved at its extremity, and beset with very strong and numerous unequal striated teeth. The third joint is articulated with the enlarged basal joint of the second, so that its similarly incurved extremity is opposable, like a thumb, to the latter. It possesses teeth of a similar structure to those in the other ramus of the chela, and opposed to them as the canine teeth in the upper jaw of a mammal are opposed to those in the lower, passing, that is, behind the others, or on their proximal side.”¹

From a careful comparison of these organs with the less rare and often better preserved remains of *Pterygotus bilobus* and *P. perornatus*, they have been placed in front of the mouth (Plate VIII, figs. 1, and 2, 2, 2). We have no evidence that the coxal, or basal joints of these chelate appendages were converted into gnathites; but the corresponding simple pair of organs in *Slimonia* and *Eurypterus* (and probably also in *Stylonurus*), are made to fulfil the office of jaws. It was probably this fact, which led Prof. Agassiz² to conclude that the antennary system was entirely absent in the *Eurypterida*, but the antennæ in *Limulus* (see Plate IX, fig. 1, 3, and 1*a*) also act as gnathites; and if we accept Prof. Huxley's view, that these chelate organs in *Pterygotus* represent the antennæ, and assume the antennules to be aborted, the remaining mouth-organs will be found to correspond exactly in number, with *Limulus*.

*The Endognaths, or Mandibles and Maxillæ.*³—The three pairs of organs which follow after the antennæ are apparently almost identical in form.

At Plate VII, figs. 5, 6, 7 and 8, represent the best detached examples of these appendages that have as yet been discovered, whilst at Plate II, fig. 1, we see several nearly entire endognaths, but too small to show more than the general outline.

The basal joint is large and flat, and produced almost to a point at one extremity (figs. 5*p* and 6*p*), where it was evidently attached to the head, and truncated obliquely to its long axis at the other. The truncated margin is slightly curved, and is beset with strong curved and pointed teeth, which are longer at one end of the series (*a*), than at the other (*b*), and are so constricted at their bases as to appear to be articulated with the basal joint (*a*, *b*, figs. 5, 6 and 7). On the outer part, immediately above the pointed extremity (*p*), is inserted the basal joint of the long palpiform appendage. The first two (?) joints of

¹ Prof. T. H. Huxley, *Surv. Mon.*, p. 14.

² Hall's 'Palæontology of New York,' 1859 (see ante, p. 18, ¶ 47).

³ This description is taken in part from Prof. Huxley's *Survey Mon.*, p. 15 (*b*).

the palpus are much shorter, and thicker than the succeeding ones, which were subcylindrical and nearly equal in length for the next succeeding three articulations, ending with two short joints, the terminal one being pointed and slightly curved. The characteristic sculpture is visible upon a portion of the surface of the basal joint of these appendages (see figs. 5—7).

The Ectognaths, or Maxillipedes.—These are by far the most complete and well-preserved of any of the appendages met with, and are represented by two basal joints, or *coxognathites* (Plate I, fig. 3, and Plate IV); by a very large penultimate joint, or *prognathite* (Plate V); by an almost entire maxillipede, or *ectognath* (Plate VII, figs. 9, 10), all of the natural size; and lastly, by part of another example (Plate VII, fig. 11), three fourths the natural size.

These mouth-appendages, which occupy the most posterior position in the series (see Plate II, figs. 1, 5, and Plate VIII, figs. 1, 6), and probably correspond to the first pair of maxillipedes in the *Decapoda*, and the sixth pair of appendages in *Limulus* (see Plate IX, figs. 1, 7), are evidently the most important and powerful manducating organs, as well as being also the principal locomotory appendages.

Prof. Huxley (op. cit., p. 16) thus describes an ectognath:—"It consists of an exceedingly large and expanded, quadrate, basal joint, produced at one angle into a broad curved process, which is obliquely truncated at its extremity. The truncated edge is nearly straight, and is serrated, broad notches separating a number of strong, flattened, pointed denticles, which are continuous with the substance of the joint, and not articulated with it (see Plates I, fig. 3 *m*, and IV, *m*.)

"The denticles or serrations form a single series, and diminish in size from one end of the series to the other. The smallest is succeeded by the rounded corner in which the truncated edge and the concave margin of the serrated process meet.

"The surface of the joint and of its process is covered with the squamiform ornamentation, and presents in the middle of the margin, opposite to the serrated process a deep notch (Plates I, fig. 3 *s*, and IV, *s*), which receives the first joint of the long palpiform remainder of the appendage. This portion consists of six articulations, the penultimate of which (Plate VII, fig. 10, *g*, and fig. 11, *g*) is much larger than any of the others, is elongated, broad, flattened, and widely emarginate at its distal extremity, where it articulates with an oval palette-like plate, with serrated edges.

"From the form of the articulating edges of the joints of the palpiform part of this appendage, I am inclined to think that, as in the chela of the lobster, the plane of motion of each joint formed a considerable angle with that of its predecessor and successor, the result of which would be a sort of feathering, or screw-propeller motion, of the ultimate and penultimate joints during flexion of the limb."¹

In the recent state these appendages undoubtedly required for their effectual action the

¹ Such an arrangement, in fact, as is to be seen in the limbs of Swimming-crabs (see Plate IX, fig. 8).

presence of large and powerful muscles, and we obtain evidence, in the thickness of the joints themselves, of the spaces which they formerly occupied. This is well seen in the coxognathite, figured on Plate I, fig. 3, which lifts out of its stony matrix, showing the opposite side (destitute of ornamentation), the stoutest part being three eighths of an inch in thickness. In aged specimens the size of the paddles must have been very great, judging from the single articulus which we figure at Plate V. This large penultimate joint (*prognathite*) measures seven and a half inches in length by four and a half inches in breadth, and has a dorsal ridge two inches in height, which, no doubt, afforded a fulcrum for the attachment of very powerful muscles.

The Metastoma or post-oral plate.—This median appendage is considered by Prof. Huxley to be formed by a fold of the integument, and not to represent a distinct somite. It is symmetrical in form, and is seen *in situ* on Plate II, fig. 1 *m*, and Plate VIII, fig. 1 *m*. It no doubt represents the *labium*, and served more effectually to enclose the posterior part of the buccal orifice, being found exterior to the toothed edges of the ectognaths or maxillipedes.

The form of this appendage is heart-shaped in *Pterygotus*, and was, no doubt, attached only by its narrow end to the posterior border of the head upon the under side (Plate III, fig. 1 *a*), with its broader and bilobed end directed forwards (Plate III, fig. 1 *p*). The surface is covered with the same characteristic scale-like markings as those seen upon the body-segments, and, like the other plicæ, they have their convexities directed backwards towards the narrow posterior border (*a*). The large post-oral plate which we figure on Plate III measures five and a half inches in length and four inches in breadth.

The Thoracic plate, or Operculum.—This plate was one of the mutilated portions of *Pterygotus anglicus* first discovered and figured by Prof. Agassiz in 1844,¹ which (together with other fragments) has been reproduced in Lyell's 'Elements of Geology.'² A fine series of the detached plates are figured in the 'Survey Monograph,' plate iii, figs. 2—7, but no specimen had at that time been discovered *in situ*.

Mr. Page first drew attention to the occurrence of this plate in its natural position in *Slimonia*,³ but considered it to be the "anal plate."

Dr. J. Nieszkowski⁴ pointed out the true position of this plate in the Russian species of *Eurypterus*, in 1858; and in 1862, Mr. Salter⁵ expressed his concurrence in the views

¹ See Bibliography, ante, p. 22, ¶ 20.

² I observe the reference to these figures in the 6th edition of Sir Charles Lyell's 'Elements of Geology' (1865), p. 523, fig. 590, has by some oversight remained unaltered. The portion of a Thoracic plate (1) is referred to the "back of the head" (as suggested by Prof. McCoy), and the fragments 3 and 4 (the first being part of a maxillipede, or ectognath, and the 2nd the chela of an antenna) still remain united. But a reference to the explanation of fig. 591, p. 524, gives the correct position of these several appendages. The central ridge, however, seen (in fig. 591) upon the penultimate joint (12) and the telson (13), ought not to have been visible, as the figure represents the *ventral aspect* of the animal.

³ See Bib., p. 27, ¶ 46.

⁴ Ibid., p. 26, ¶ 43.

⁵ Ibid., p. 28, ¶ 51.

of Dr. Nieszkowski and Professor Hall,¹ and corroborates their statements, on the evidence of specimens in the collection of Mr. Robert Slimon, of Lesmahagow, Lanarkshire.² In a paper published in 1863 I described one of these thoracic plates, which had been found by Mr. Slimon, attached to a very perfect specimen of *Slimonia acuminata*.³ If any uncertainty still existed as to the position of this organ, its discovery in place, in *Eurypterus*, *Slimonia*, and in two species *Pterygotus*, ought to preclude all further doubt.

This plate is well seen, in its normal position, *i.e.* upon the ventral surface of the fossil behind the head, and overlying the two first free thoracic somites, in the figure of the entire body of *Pterygotus*, Plate I, fig. 1 *c*; and it can also be discerned on the young specimen figured upon Pl. II, fig. 1. We have represented it in the restored figure of this species, at Pl. VIII, fig. 1, *op.*

Portions of five of these opercular plates are figured in the Survey Monograph on *Pterygotus* (Pl. iii, figs. 2, 3, 4, 5, and 7), but it was at that time assigned to the head, as the conjoined epistoma and labrum, being, as before stated, only known from detached and imperfect specimens. This plate (which is closely sculptured with the same characteristic scale-like markings as those seen upon the body segments, especially at its anterior or attached border) is divisible into three well-marked regions: 1st, a narrow, central lobe, rounded at its distal free end, and hastate at its proximal end, which is directed forwards, and nearly touches the posterior margin of the labium (Plate I, fig. 1 *c*). Secondly, two wide lateral alæ, which are united to the sides of the narrow median lobe, and rounded off at their lateral and posterior free borders, but are nearly parallel along the anterior margin, by which it was, no doubt, attached to the head. The free extremity of the median appendage projects beyond the lateral alæ, forming together a border very like a bracket, thus:



a a being the lateral alæ, and *c* the projecting median lobe.

In some specimens a faint indication of a suture is to be discerned on the centre of this median appendage, and in *Eurypterus lanceolatus*⁴ the division is very clearly marked.

One cannot fail to notice the great resemblance which exists between the thoracic plate, or operculum, of these palæozoic crustaceans and the corresponding plate in the recent *Limulus* (Plate IX, fig. 1, 8, and fig. 1 *c*).

Its position is the same in each—being attached to the posterior part of the head-shield. In *Limulus*, the median part is double, being composed of a pair of jointed appendages (see Pl. IX, fig. 1 *c*, *d*, *d*), but in young *Limulus* these are anchylosed together, as is the case in *Eurypterus* and *Pterygotus*.⁵ Professor Hall evidently considers

¹ See Bib., p. 28, ¶ 47.

² Ibid., p. 25, ¶ 35.

³ Ibid., p. 29, ¶ 53.

⁴ Geol. Mag., vol. i, pl. v, fig. 8.

⁵ See the observations of Prof. Agassiz, in Hall's Palæontology of New York, Part vi, vol. iii, p. 395.

the lateral alæ of this plate in *Eurypterus* to be composed of the sternal pieces of the first and second thoracic segments welded together.¹ But the thoracic plate, or operculum, in the *Eurypterida*, is formed upon precisely the same plan as in the *Xiphosura*, namely, by the coalescence of the last pair of appendages of the cephalic buckler, and it only lies folded close to the under side of the anterior somites. The lateral expansions on each side the median appendage are united to it, and really form a part of this pair of modified legs, which, in *Limulus*, bear upon their inner and upper surface a pair of ovaries or reproductive organs.

In *Limulus* the operculum (Pl. IX, fig. 1, 8, and fig. 1 c) is succeeded by five other membranaceous anchylosed pairs of appendages, alike to it in form, but thinner, and bearing branchiæ upon their inner and upper surface. It is reasonable to assume that the *Eurypterida* also possessed these organs, and that, in all probability, the opercular or thoracic plate carried the former (*i. e.* the sexual organs), whilst one or more thinner plates, destitute of scale-like markings upon their surfaces, were concealed beneath it, as the branchial plates lie hidden beneath the operculum in *Limulus*, but which are extended in the act of swimming.

The thoracic plate, or operculum, may then be regarded, not as a median appendage, like the metastoma, or post-oral plate, but as a pair of coalesced appendages, making seven pairs of organs to the head. (See Plate VIII, fig. 1.)

The body of *Pterygotus* is seen to be composed of twelve somites or segments, and a telson, or terminal joint; the surface of both the upper and the under sides is covered with scale-markings, which are more numerous along the anterior half of each segment than near the posterior border, which is usually plain. The segments gradually increase in width from the head backwards to the fifth segment, when they as gradually become narrower to the eighth; the breadth then decreases more rapidly, and the length of the segments is considerably increased, until, in the specimen on Pl. II, fig. 1, the twelfth segment is as long as it is wide. The form of the margins of the anterior segments is extremely parallel, as well seen in the remarkably fine detached segment figured on Plate II, fig. 2, the original of which measures eighteen inches in breadth.

This was probably about the third segment from the head, and is more than four

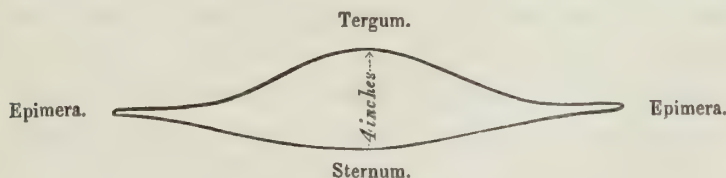


FIG. 5. Section of anterior part of the body in *Pterygotus anglicus*.

¹ Op. cit., 398.

times as wide as it is long. It is strongly arched in the centre, and the body at this point was not less than three to four inches in thickness. When seen in section it presents somewhat the form represented in the accompanying woodcut. (Fig. 5.)

Two apodemata are directed forwards on either side from the epimera of the anterior border of this somite (Plate II, fig. 2, *a, a*), by which it was evidently united to the preceding segment. The other body-rings were, in all probability, joined together by similar internal processes from the shelly-envelope, affording solid points of attachment for the powerful muscles which doubtless formed—as in the Macrouran Decapod—almost the entire bulk of the huge apodal trunk in *Pterygotus* and its allies.

As we recede from the head, we find that, at about the seventh, or first abdominal somite, the posterior edge becomes more curved, and there is a slight tendency along the lateral borders to develop into falcate epimeral extensions. The last three segments become slightly keeled along the centre of the tergum, and the border of all the posterior segments is somewhat bluntly serrated.

The very perfect ante-penultimate body-segment which we have figured on Pl. III, fig. 2, having both its upper and under surfaces preserved, shows the exact thickness of this somite to have been three inches: an end view gives a section as under. (Fig. 6.)

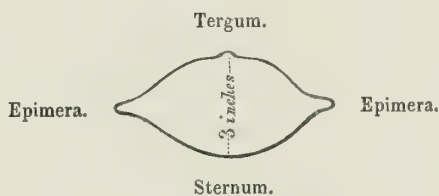


FIG. 6. Section of posterior part of the body of *Pterygotus anglicus*.

Mr. Salter, in his description of *Pterygotus anglicus*,¹ gives a woodcut of a segment extremely like the one figured on Pl. III, fig. 2, showing both the upper and under side. The specimen is stated to be from Leysmill, Forfarshire, and may possibly be the same example. He calls attention² to the variation which is noticeable in the form of these posterior segments, and suggests that the difference may be due to sex, and not to any specific distinction.

The telson, or terminal segment, is obtusely hastate, and strongly keeled upon its dorsal surface. It varies apparently with the age of the individual (see Pl. I, fig. 1 *t*, Pl. II, fig. 1, and Pl. VI). There are no scale-markings visible on this appendage,

¹ 'Mem. Geol. Surv.,' Mon. I, p. 71, fig. 10.

² Op. cit., p. 72.

except near its proximal or attached end, but it is ornamented with rough, blunt squamæ and serrations along the lateral margins.

The telson figured on Pl. VI is the largest known, and measures nine inches in length by seven inches in breadth.

In describing the divisions of the body in *Pterygotus anglicus*, we have spoken of the head and the body, avoiding the terms "thoracic" and "abdominal somites" as much as possible. On reference to the restored figure at Plate VIII, fig. 1, it will be seen that there is evidence, according to the paired appendages (see *antè*, p. 6), of 7 somites having coalesced to form the cephalic division.

Assuming that all the segments united to form the head are represented by pairs of appendages, we have then a true Cephalon; the 7 succeeding free somites are thoracic, the abdomen being represented by 5 somites¹ and a telson, or terminal joint. But assuming the antennules to be wanting (see *antè*, p. 37), we must conclude the head to represent 8 coalesced segments, that is to say, 7 cephalic and 1 thoracic, the latter bearing the "operculum," or "thoracic plate" (Pl. VII. fig. 1 *op*).

In this case only the first six anterior somites will be counted as thoracic, the posterior six will be reckoned as abdominal, and the 'telson' will make up the 21 segments.

The likeness which *Pterygotus* offers to *Limulus* is very much strengthened by this latter view. As we proceed to the illustration of the other genera belonging to this order, we shall be still more strongly impressed with the many points of close resemblance which they will be found to exhibit.

The *Merostomata* seem, in fact, to present us, in these early times, with a parallel group of *Crustacea* to that embraced in the order *Decapoda* at the present day; the *Macroura* being represented by *Pterygotus* and its allies, the *Brachyura* by *Limulus*, &c., and the intermediate forms, like *Hemiaspis*, &c., being comparable to the *Anomoura*.

We could scarcely, in the whole Zoological Kingdom, point to a stronger illustration of the persistence of type than is to be observed in these Palæozoic forms.

From our present knowledge of the almost perfect remains of *Pterygotus anglicus*, and on the evidence of the numerous detached portions of this extinct genus, we are justified in concluding that it attained a length of six feet, and a breadth of nearly two feet at the widest part of its body.

From its large eyes, its powerful natatory appendages, and from the general form of its body, we may also infer that it was a very active animal. Its great prehensile antennæ and rows of serrated jaws, further indicate its predacious habits, whilst from its size it must have been the shark of the Devonian seas.

"No existing Crustacean," observes Prof. Huxley, "has so massive a body as *Pterygotus*," . . . "but mass in an active animal involves large muscles, and

See Dr. Milne-Edwards' observations on arrested development, *antè*, p. 6.

these require solid *points d'appui*. Hence, we may conclude that the integument of the *Pterygotus*, thin and fragile as are its remains, possessed a great amount of firmness in the recent state."¹ In the living *Limulus*, the shell is equally thin to that of the fossil *Pterygotus*, but this leathery integument nevertheless affords attachment to very powerful muscles.

Distribution.—This species is peculiar to the LOWER OLD RED SANDSTONE, and has been obtained at Balruddery, Perthshire; at Leysmill near Arbroath, at the quarries of the Turin Hills, near Reswallie, at Tealing and Carnyllie, and other places in Forfarshire.

The specimens figured are from the collections of Lady Kinnaird, James Powrie, Esq., the British Museum, and the Watt Institution, Dundee.

¹ 'Mem. Geol. Surv.,' Mon. I, p. 36.

PLATE I.

DEVONIAN CRUSTACEA.

Order—MEROSTOMATA.

Sub-Order—EURYPTERIDA.

FIG.

1. An almost entire body of *Pterygotus anglicus*, Agassiz, the original specimen measuring 23 inches in length, preserved on a slab of grey micaceous sandstone from Turin Hill range, Forfarshire. Two thirds natural size. See page 34.
2. A detached head of *Pterygotus anglicus*, Ag., figured of the natural size, showing the marginal eyes (*e*, *e*). See page 36. From the Old Red Sandstone, Forfarshire.
- 2*a*. A small portion of the surface of the head, enlarged.
3. Basal joint of the left maxilliped of *Pterygotus anglicus*, Ag. (natural size), from the Old Red Sandstone, Forfarshire. See page 38.
4. *Pterygotus minor*, H. Woodw. (natural size), from the indurated shale overlying the "Arbroath Paving-stone," Farnell, Forfarshire. See page 35.

The above specimens are all from the Museum of James Powrie, Esq., F.G.S., Reswallie, Forfar.

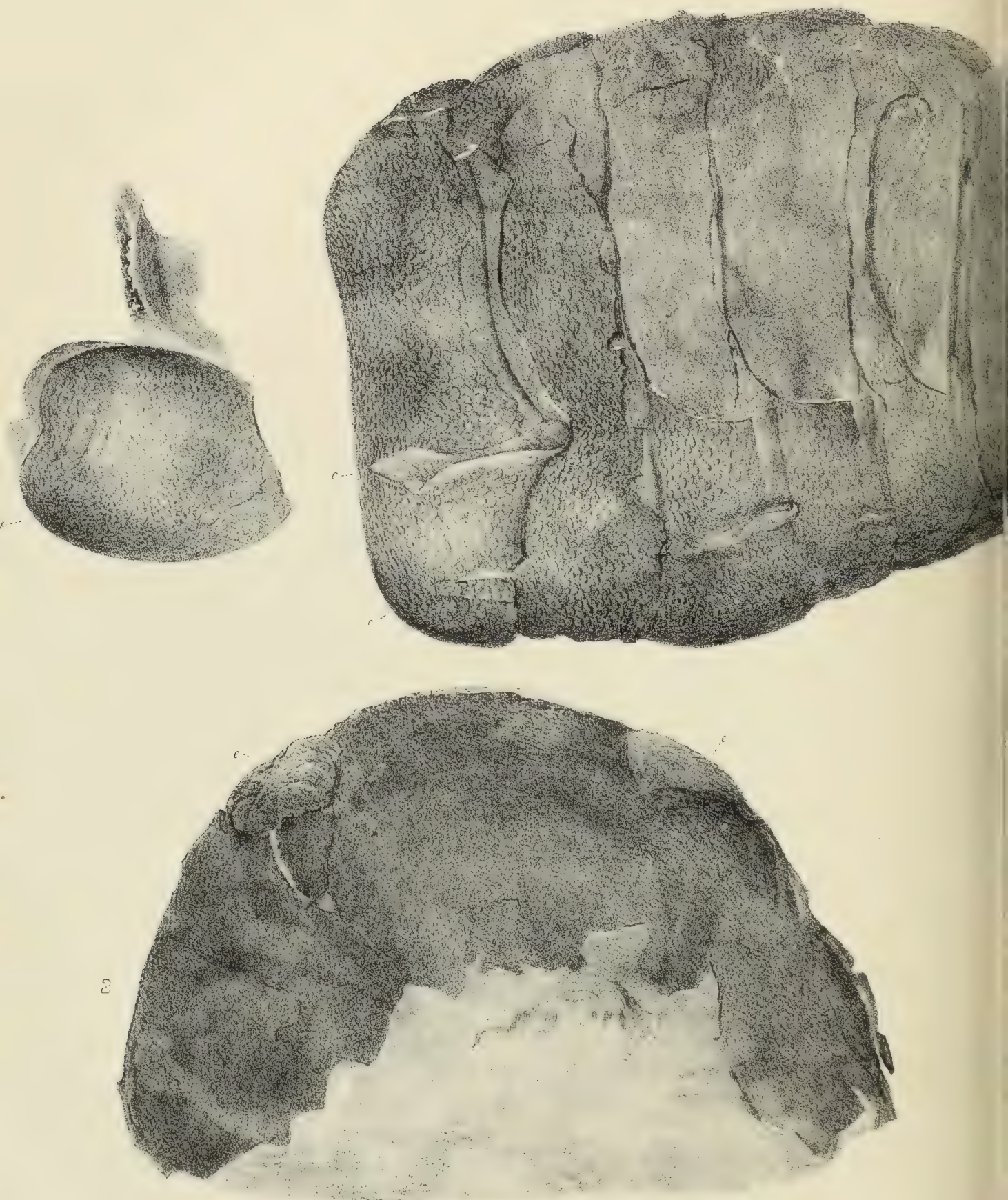


Fig. 1 3 PTERYGOTUS ANGLICUS, Agassiz
(Fig. 1. reduced one third)

1



F. Waller imp

Fig 4 PTERYGOTUS MINOR, H. Woodw
(Figs 2, 3 & 4, nat. size.)



PLATE II.

DEVONIAN CRUSTACEA.

Order—MEROSTOMATA.

Sub-Order—EURYPTERIDA.

FIG.

1. *Pterygotus anglicus*, Ag. (natural size), from the indurated shale overlying the "Arbroath Paving-stone," Turin Hill range, near Forfar. One of the most entire specimens obtained. See page 34.

The dorsal surface is exposed to view; but the organs of the mouth, &c., are seen impressed through the integument of the head-shield.

From the Museum of James Powrie, Esq., F.G.S., Reswallie, Forfar.

2. *Pterygotus anglicus*, Agassiz. Probably about the third, or fourth body-segment of a very large individual, the original measuring 18 inches in breadth and $4\frac{1}{4}$ in depth. From the Devonian of Forfarshire. See page 41.

The original specimen is preserved in the British Museum.

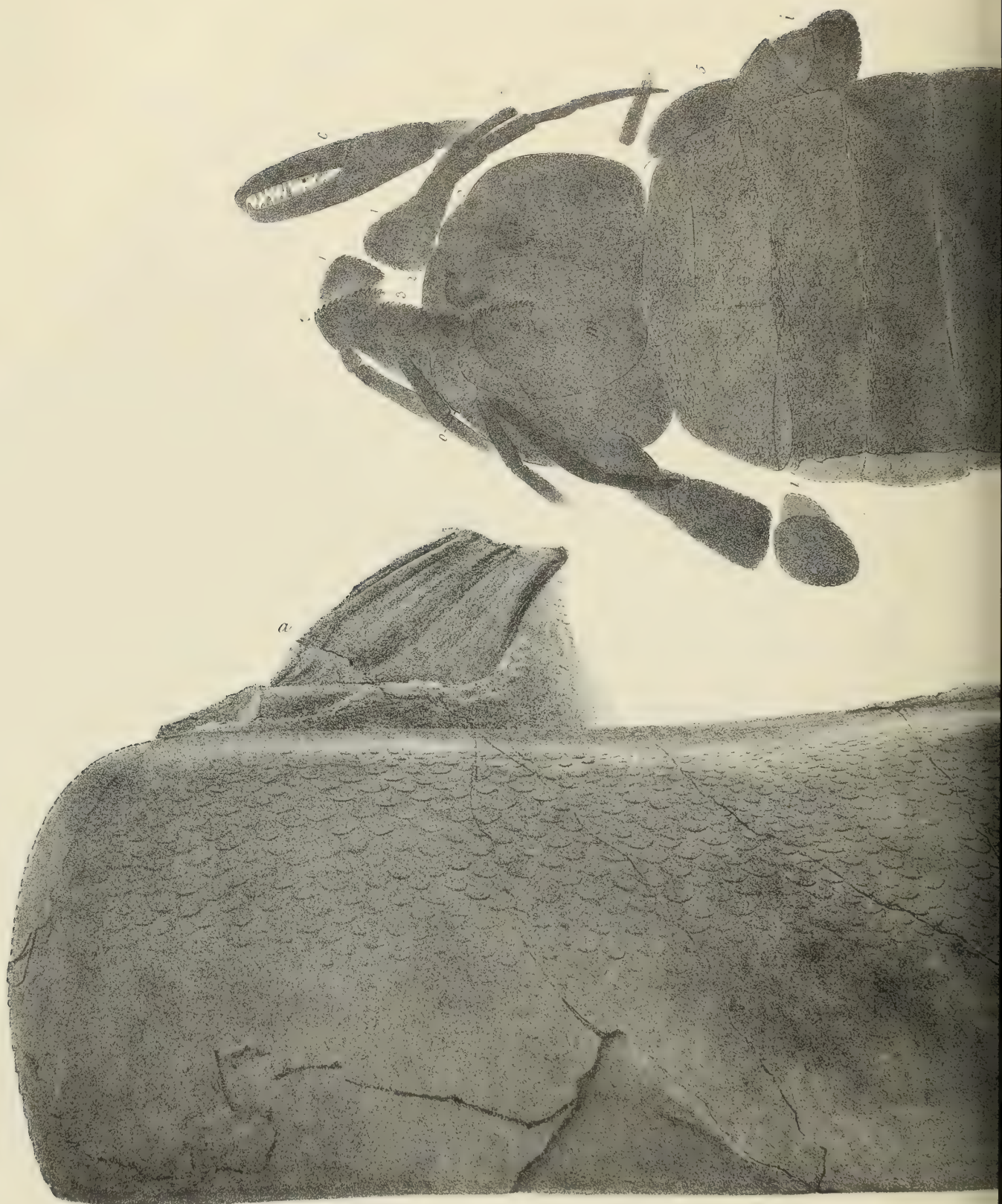


Fig. 1. PTERYGOTUS ANGLICUS Agassiz (nat. st.)

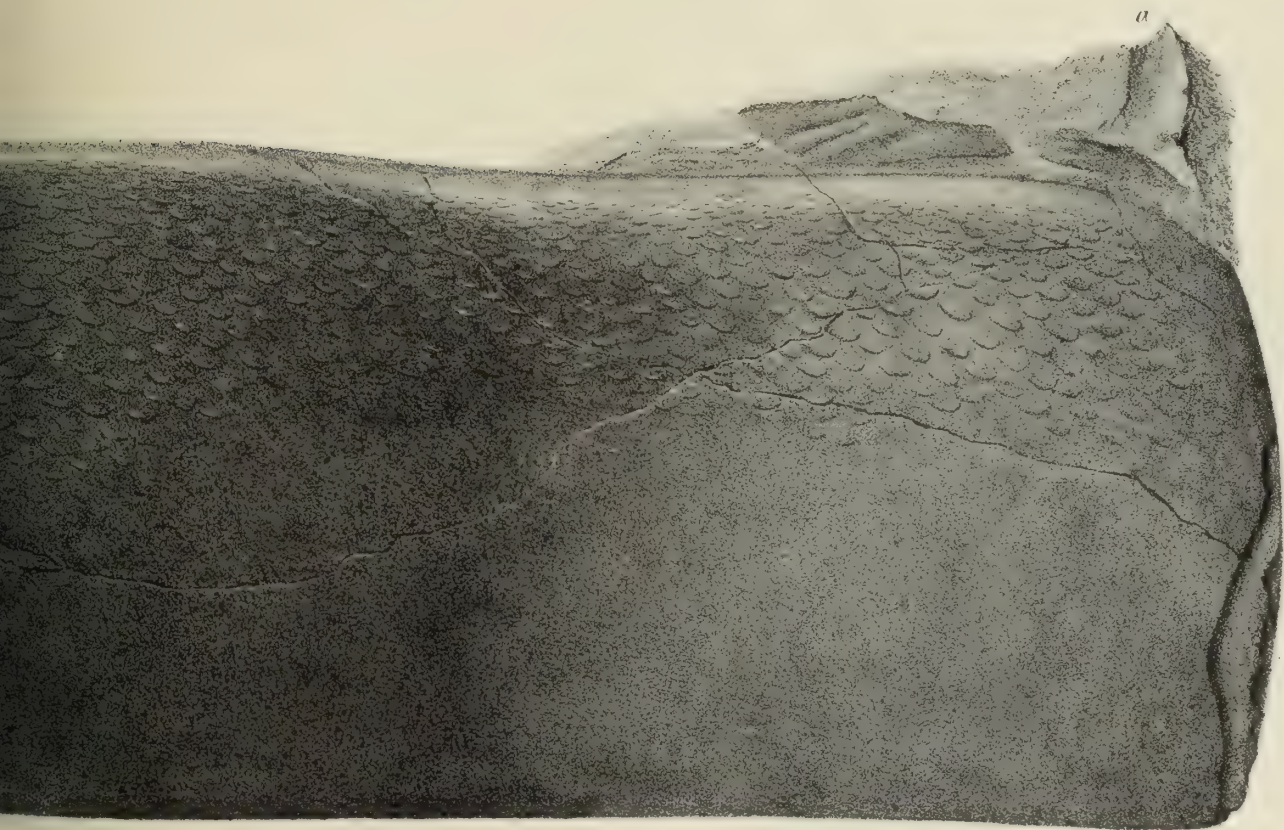
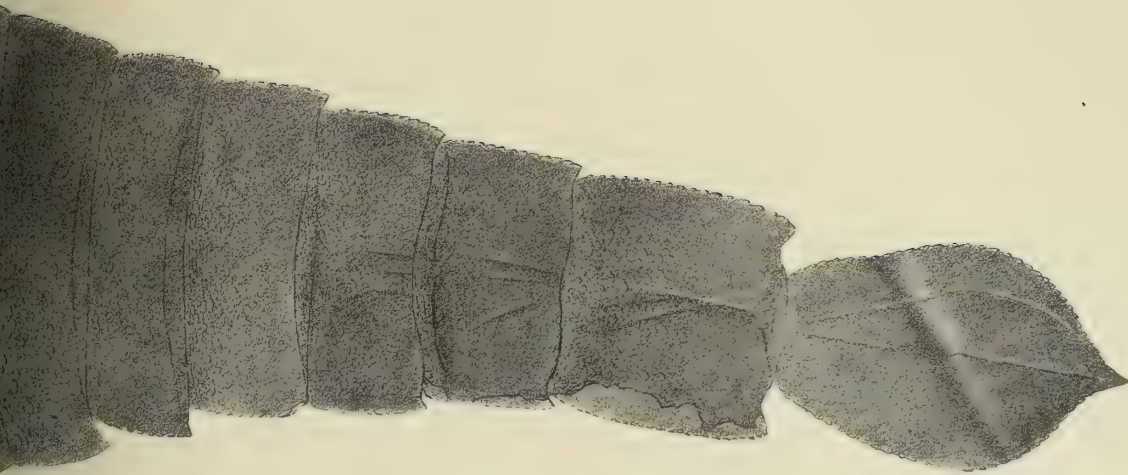


PLATE III.

DEVONIAN CRUSTACEA.

Order—MEROSTOMATA.

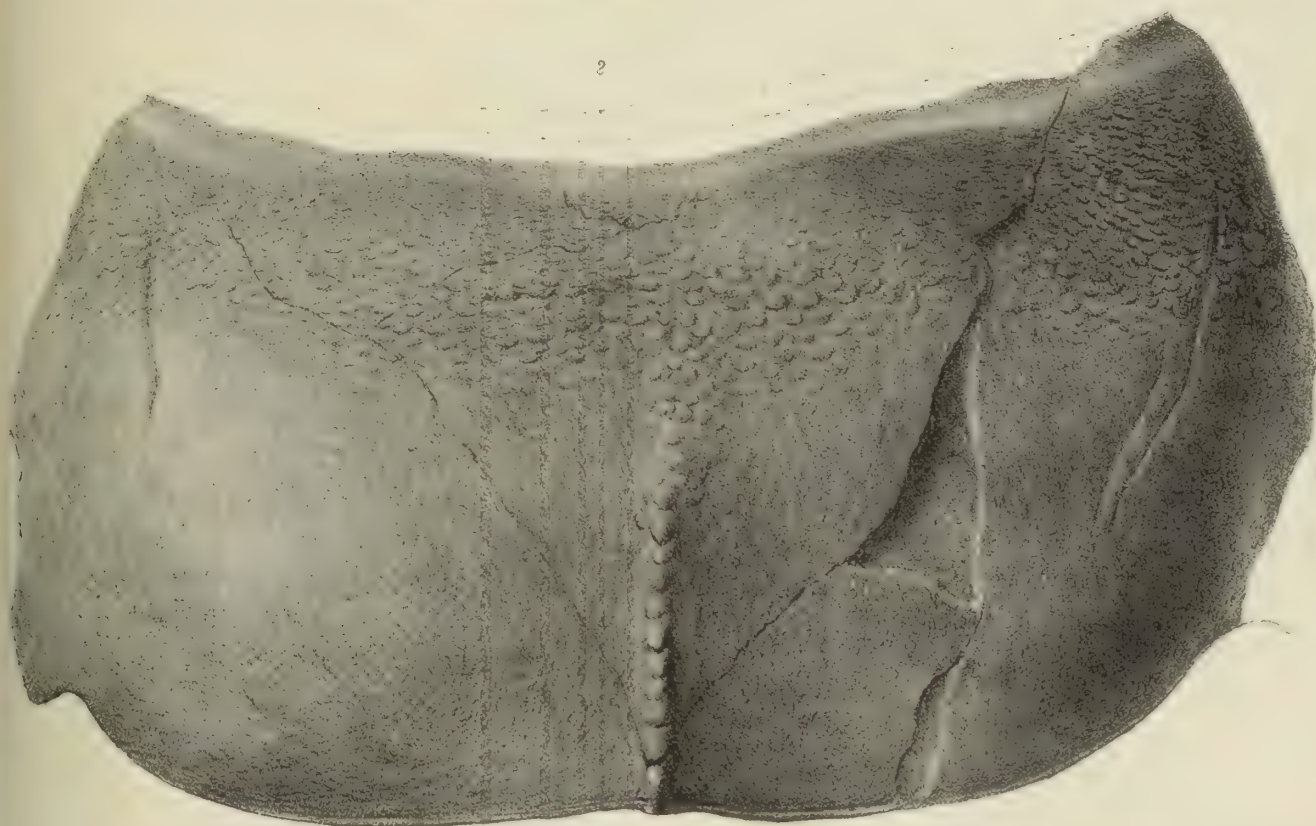
Sub-Order—EURYPTERIDA.

FIG.

1. A metastoma or post-oral plate of *Pterygotus anglicus*, Ag., figured of the natural size, from the Devonian of Forfarshire. See page 39.
2. Antepenultimate body-segment (corresponding in position to the segment marked *a* in fig. 1, Plate I); the upper surface is here represented of the natural size. From the Devonian of Forfarshire. See page 42.

The original specimens are preserved in the British Museum.

A large, dark, irregularly shaped object, possibly a fossil or a piece of wood, mounted on a light-colored background. The object has a rough, textured surface and a small, lighter-colored area on the right side. A dashed line is visible on the left side of the object.

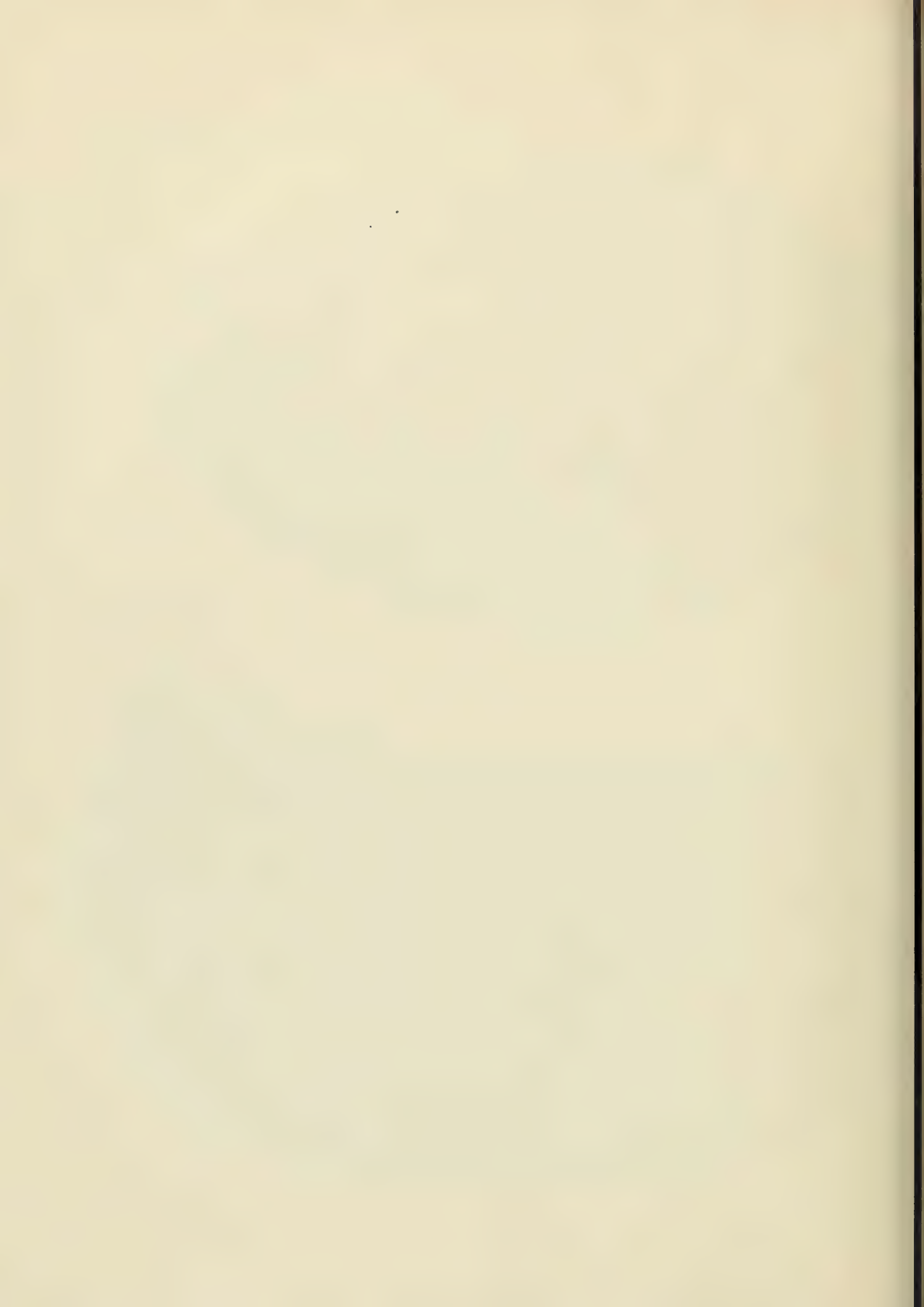


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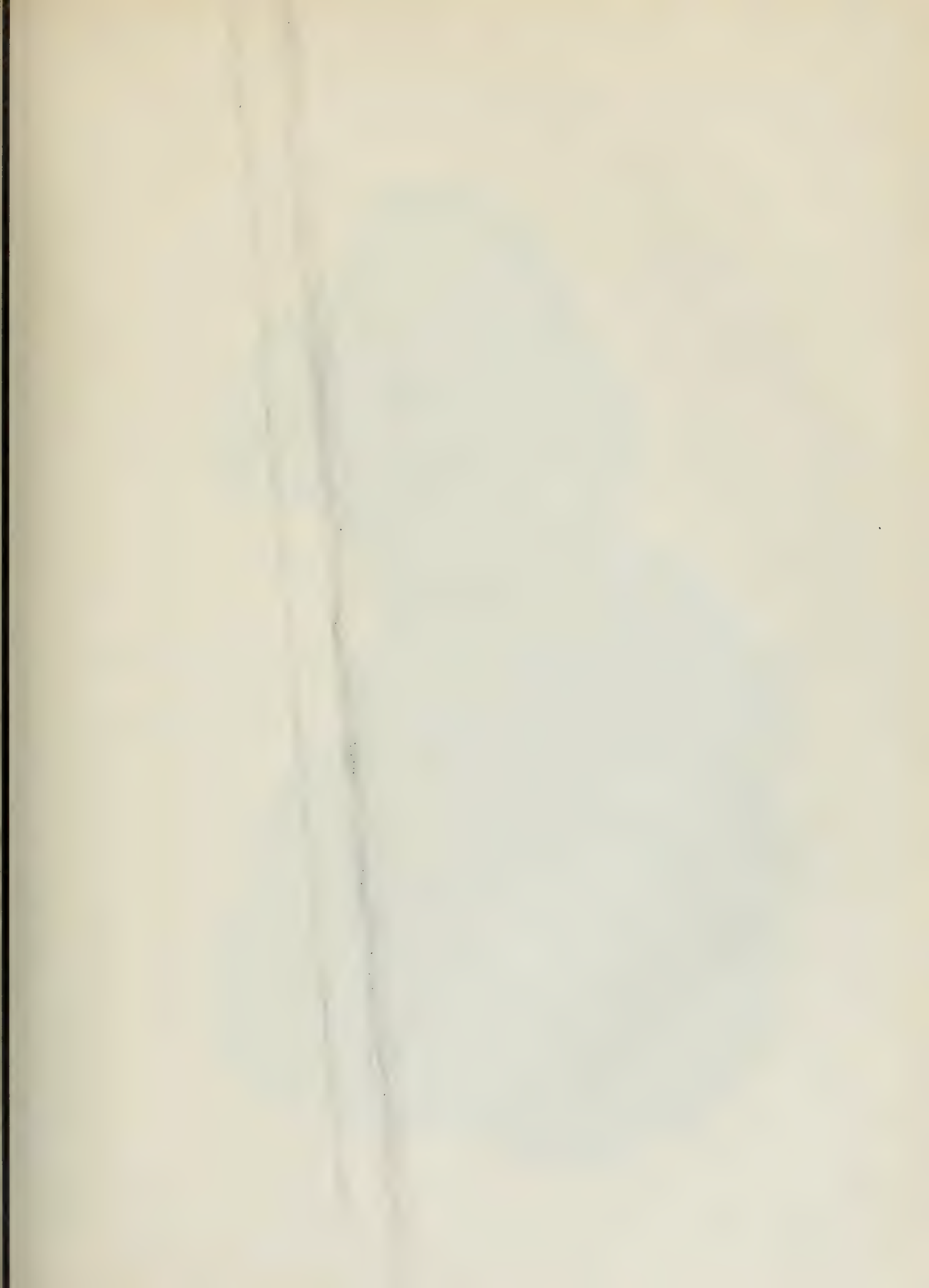


PLATE IV.

DEVONIAN CRUSTACEA.

Order—MEROSTOMATA.

Sub-Order—EURYPTERIDA.

Basal joint of a left maxilliped (or *ectognath*) of *Pterygotus anglicus*, Agassiz, figured of the natural size, from the Devonian of Forfarshire. See page 38.

m, the toothed mandibular border; *s*, the point of articulation for the proximal end of the swimming-foot. (See Plate VIII, fig. 1, 6.)

The original specimen is preserved in the British Museum.

DEVONIAN CRUSTACEA



R. Melding del et lith.

M. F. Hamlin 1914

BASAL JOINT OF A SWIMMING FOOT (nat. size) PTERYGOTUS ANGLICUS. ADAMS

FORFARSHIRE



PLATE V.

DEVONIAN CRUSTACEA.

Order—MEROSTOMATA.

Sub-Order—EURYPTERIDA.

FIG.

- 1--4 Represent the detached penultimate joint of the swimming-foot or maxillipede (*prognathite*, Huxley) of *Pterygotus anglicus*, Agassiz, from the Devonian of Forfarshire. Figured of the natural size. (See pages 38 and 39.)
- 1 Represents the outline of the joint as seen from the under surface. (See Plate VIII, fig. 1, 6.)
 2. Side view of same, exhibiting the upper surface and the ridge (*r*); *p*, proximal articular surface; *d*, distal extremity, to which the oval terminal palette was articulated.
 3. View (foreshortened) of joint as seen from the proximal end (*p*), showing the under side and the ridge (*r*) upon the dorsal surface, somewhat bent over to one side.
 4. Section (drawn from careful measurement) of about the centre of the joint, showing the thickness of the internal portion. (*r* represents the ridge, as in figs. 2 and 3.)

From the Museum of James Powrie, Esq., F.G.S., of Reswallie, Forfarshire.

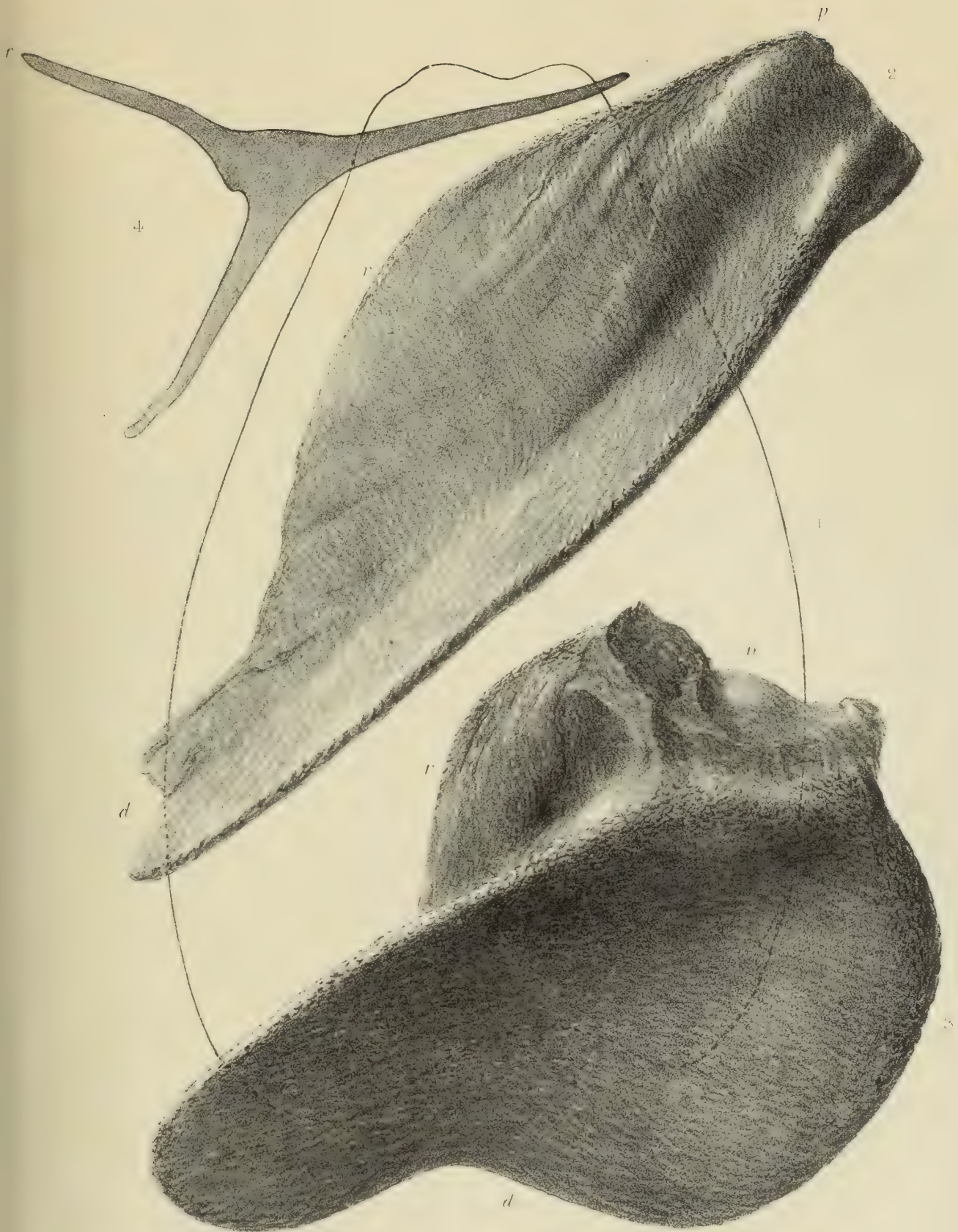


PLATE VI.

DEVONIAN CRUSTACEA.

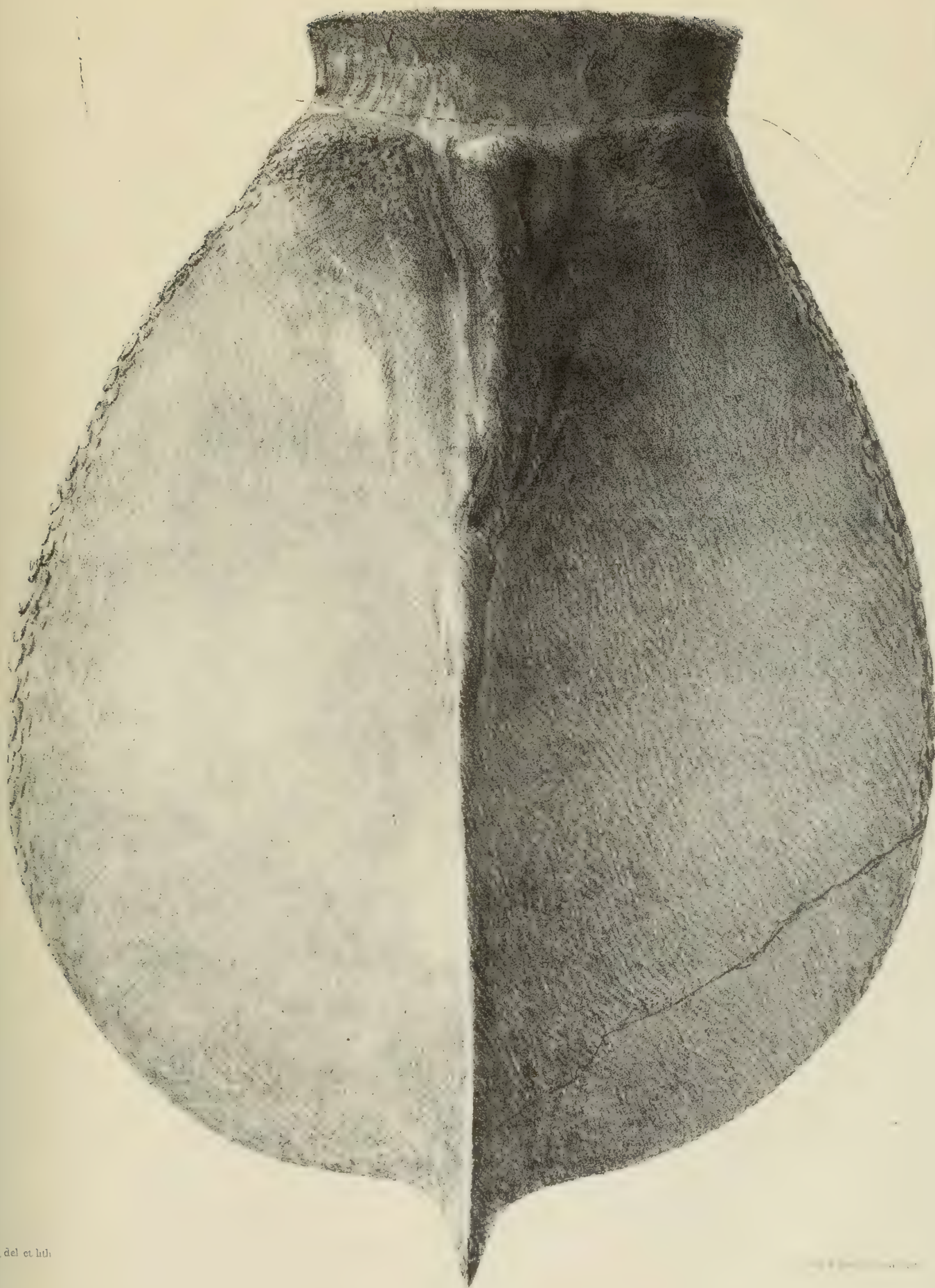
Order—MEROSTOMATA.

Sub-Order—EURYPTERIDA.

The largest telson or terminal joint which has yet been discovered of *Pterygotus anglicus*, Agassiz. From the Old Red Sandstone near Forfar. Figured of the natural size. See page 42.

The distal border of the penultimate joint, to which it was attached, is indicated in outline.

From the Collection of James Powrie, Esq., F.G.S., Reswallie, Forfar.



Fielding, del et lith.

Telson of PTERYGOTUS ANGLICUS, Agassiz. (Nat. Size)

FORT ARSHIRE.





PLATE VII.

DEVONIAN CRUSTACEA.

Order—MEROSTOMATA.

Sub-Order—EURYPTERIDA.

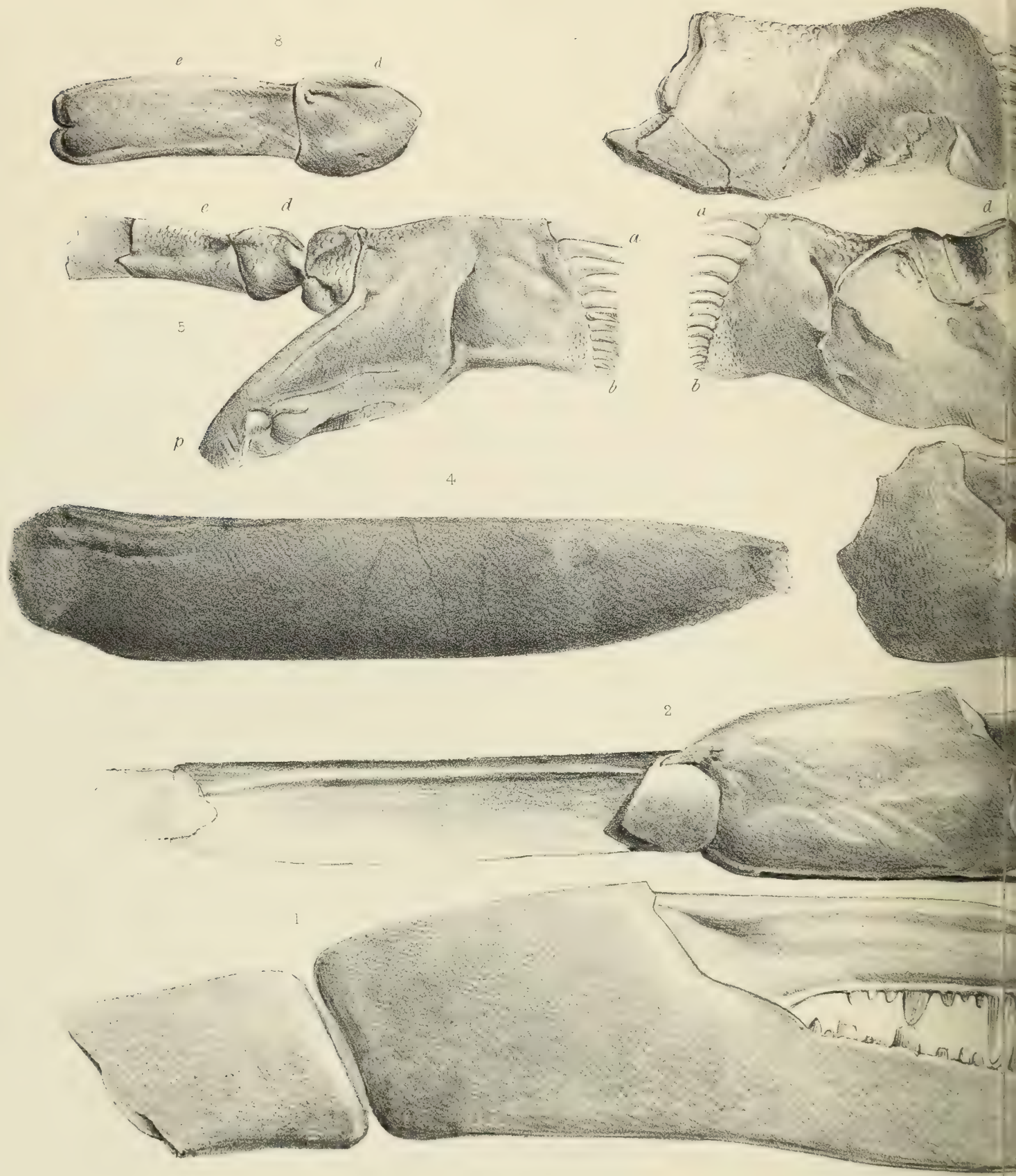
Appendages of *Pterygotus anglicus*, Agassiz. Copied (with the exception of fig. 4) from Plates VI and VII of Messrs. Huxley and Salter's Monograph, from the admirable drawings of Mr. C. R. Bone.

FIG.

1. One of the chelate antenna, the largest known. From Forfarshire. Page 37.
From Lady Kinnauld's Museum, Rossie Priory, Perthshire.
2. Another specimen, smaller than fig. 1, but having three of the articulations preserved, p. 37.
3. Chelate termination of an antenna, having the extremities of the chelæ preserved, p. 37.
From the Watt Institution, Dundee.
4. Antepenultimate joint of antenna, natural size. From Forfarshire, p. 37.
In the British Museum.
5. One of the mandibles or maxillæ (endognath, Huxley), with the first three joints of its palpus, p. 37.
From the Watt Institution, Dundee.
6. Another similar appendage from the opposite side of the head, with four joints of the palpus preserved.
From the Museum of Lady Kinnauld, p. 37.
7. A detached mandible or maxilla, differing somewhat in form from figs. 5 and 6, p. 27.
From the Watt Institution, Dundee.
8. The second and third joints of a large palpus, p. 37.
From Lady Kinnauld's Museum.
- 9 & 10. A maxilliped (ectognath, or swimming-foot), having the several articulations nearly all united to the broad basal joint, which has, however, been broken off at its serrated border, and is restored in outline at *a*, p. 38.
From the Museum of Lady Kinnauld.
11. Part of a very large swimming-foot reduced to three fourths its natural size. The letters refer to the corresponding joints in fig. 10, p. 38.
From the Museum of Lady Kinnauld.

All these specimens are of the natural size except fig. 11.





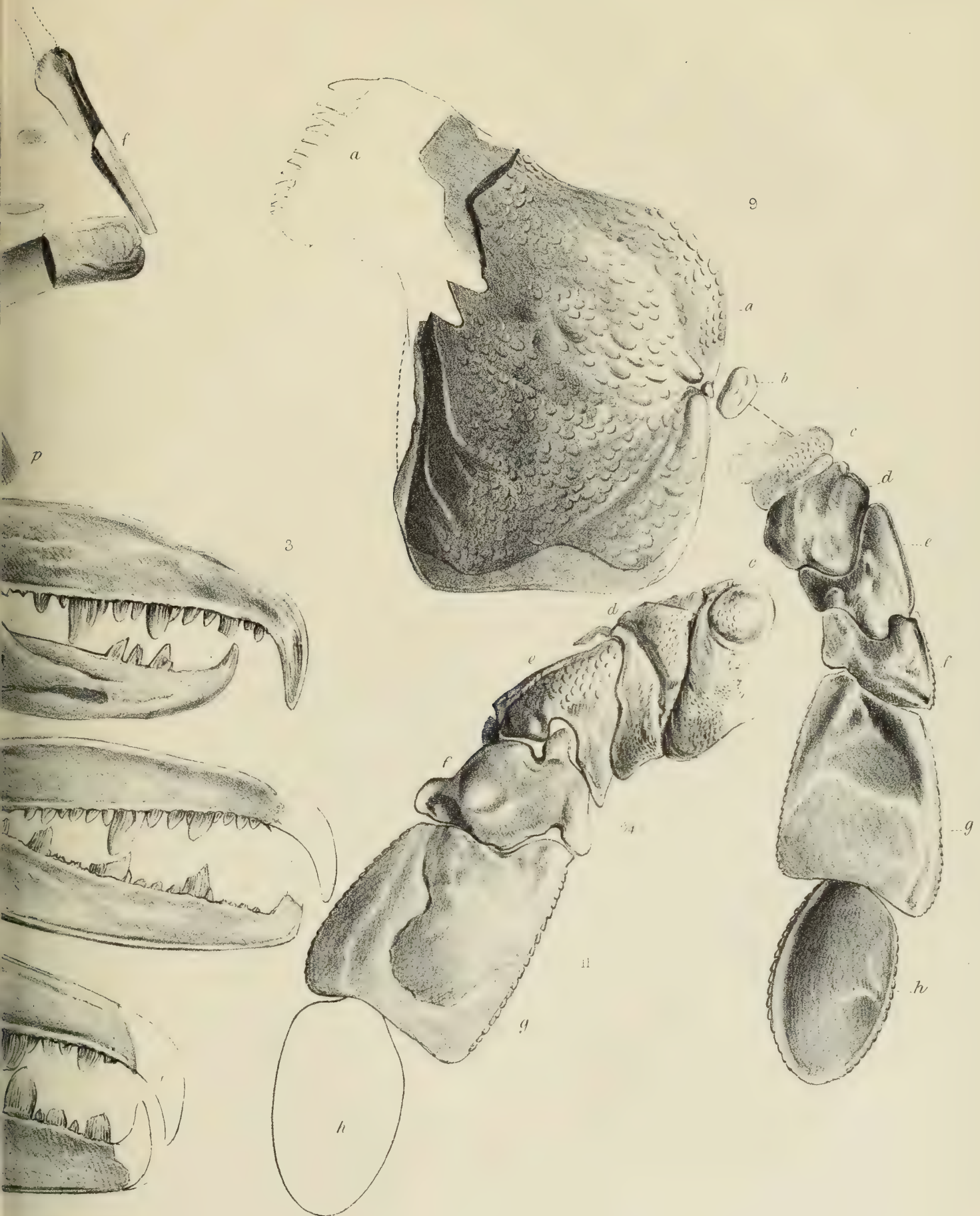


PLATE VIII.

DEVONIAN CRUSTACEA.

Order—MEROSTOMATA, *Dana*.

Sub-Order—EURYPTERIDA.

FIG.

1. Under side of *Pterygotus anglicus*, Agassiz, restored.
2. Upper side of ditto.

Fig. 2. *l*. Larval eye-spots (*ocelli*).

„ 1. *m*. The metastoma or post-oral plate.

„ 1. *op*. The operculum (representing the coalesced pair of appendages belonging to the viith somite).

„ 1. *a*. Anal aperture.

Figs. 1, 2. 1. The eyes.

„ 2. The chelate antennæ.

„ 3. The mandibles (endognaths, Huxley).

„ 4. First maxillæ (ditto „).

„ 5. Second ditto (ditto „).

„ 6. Maxillipeds (ectognaths, „).

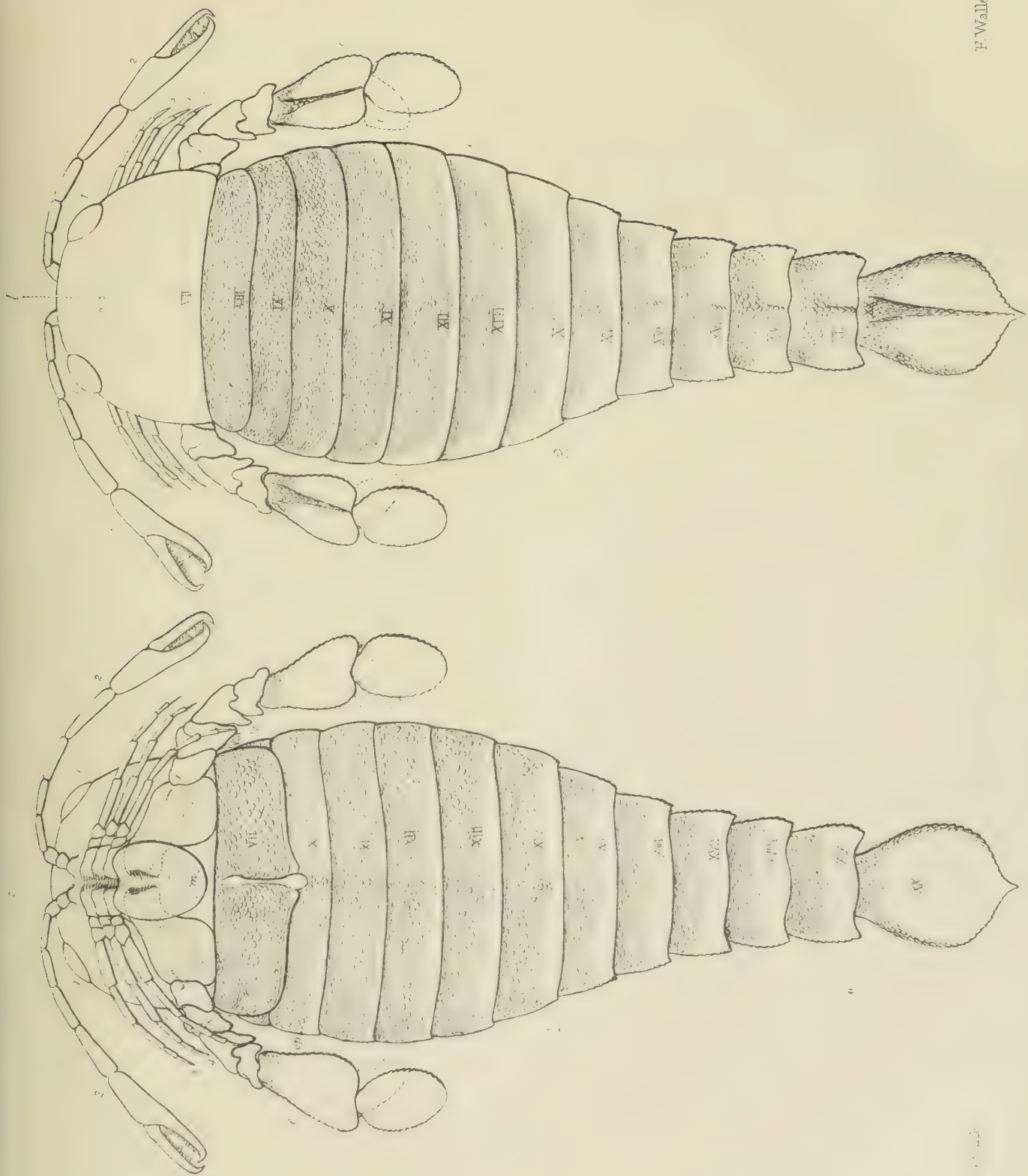
i, i. Position of small somewhat triangular plate united to the border of the penultimate joint, and overlapping the oval terminal palette. (See page 35.)

„ vii. The head-shield, bearing the *ocelli* (*l*) and large compound eyes (1, 1), and the operculum, or thoracic plate, which covers the two anterior thoracic somites (viii and ix) upon their ventral surfaces.

„ viii—xiv. Thoracic somites.

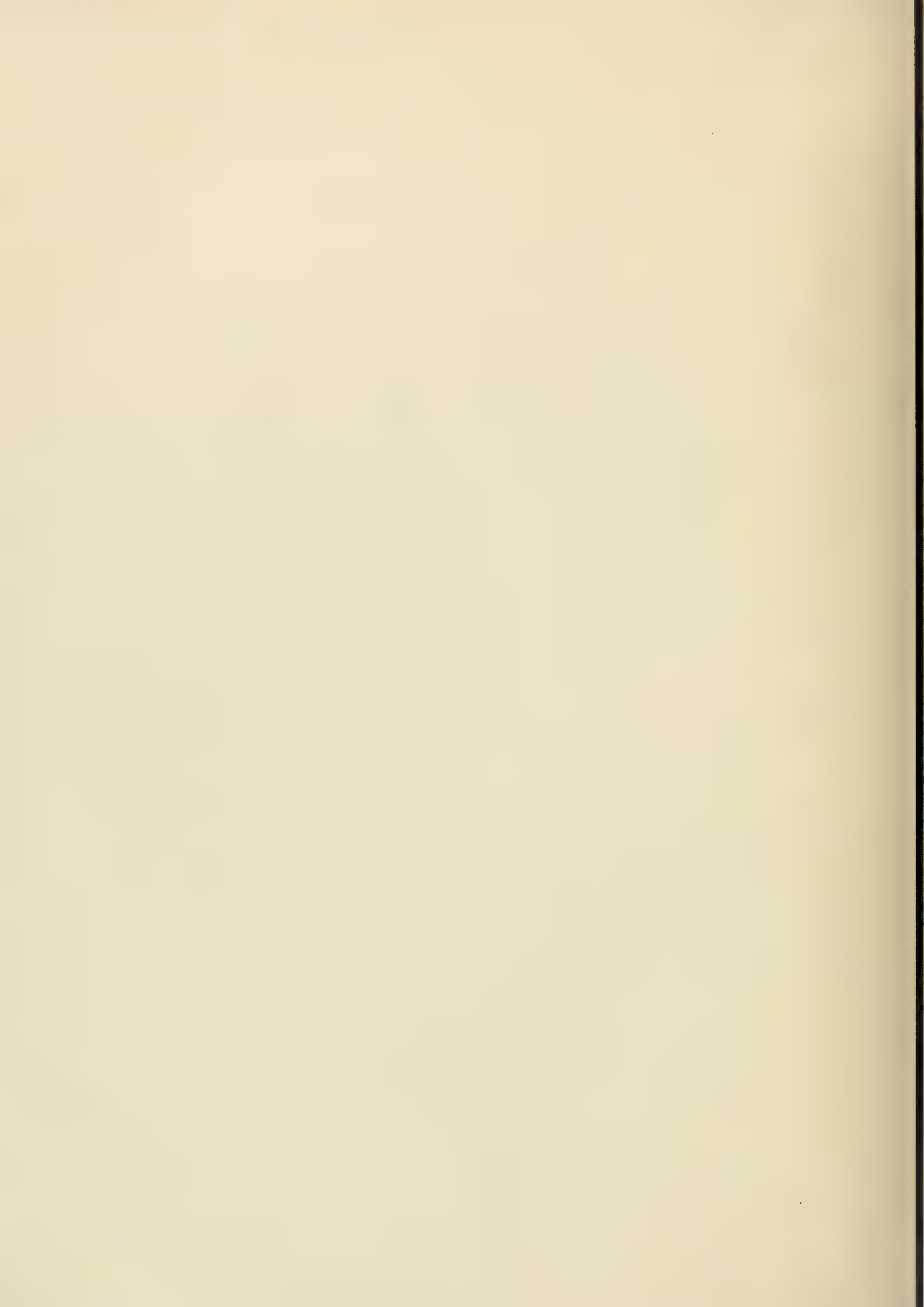
„ xv—xix. Abdominal somites.

„ xx. The ‘telson’ or terminal segment.



H. Waller imp.

PTERYCOTUS ANCLICUS, *Agassiz*. (Restored.)



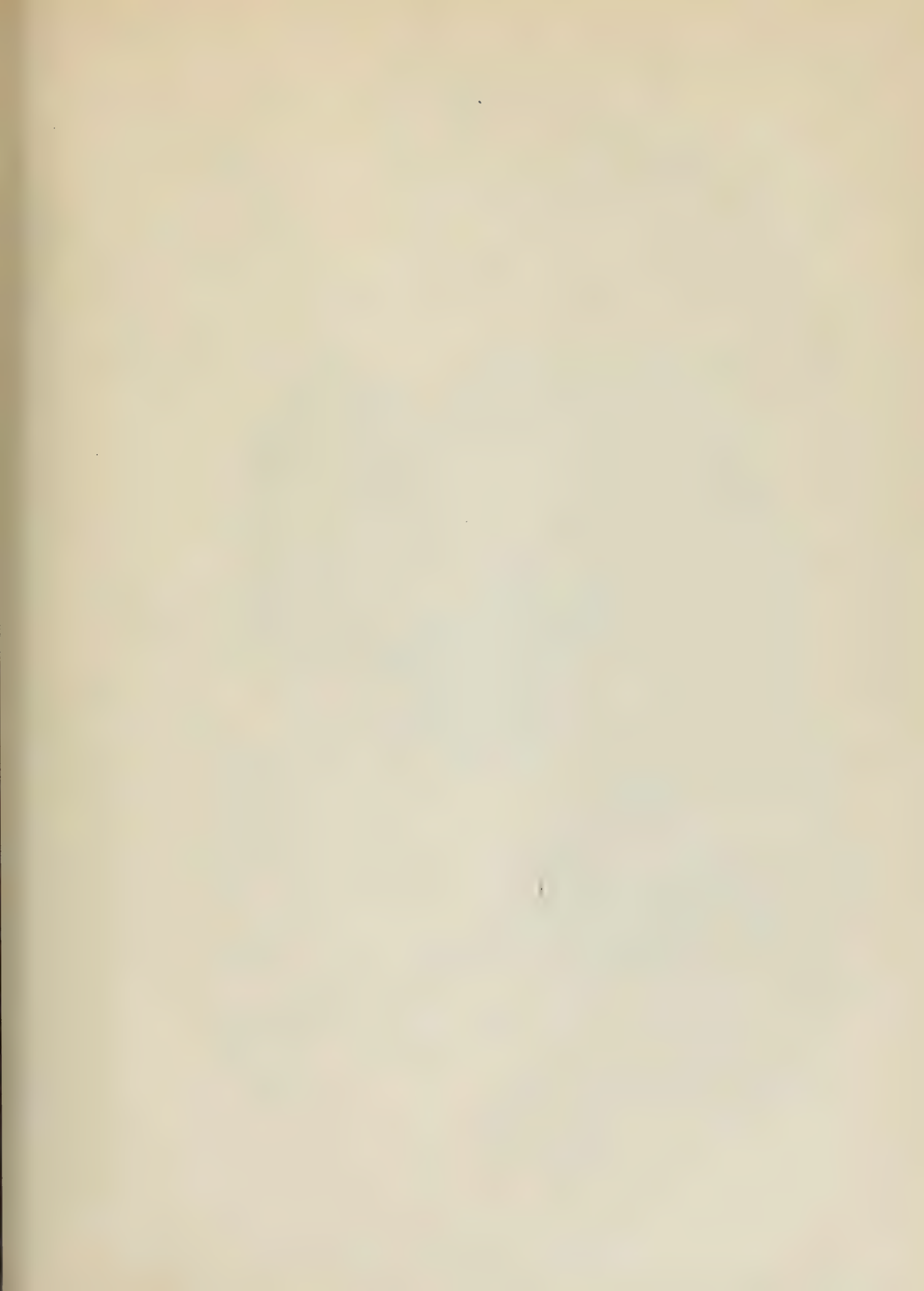


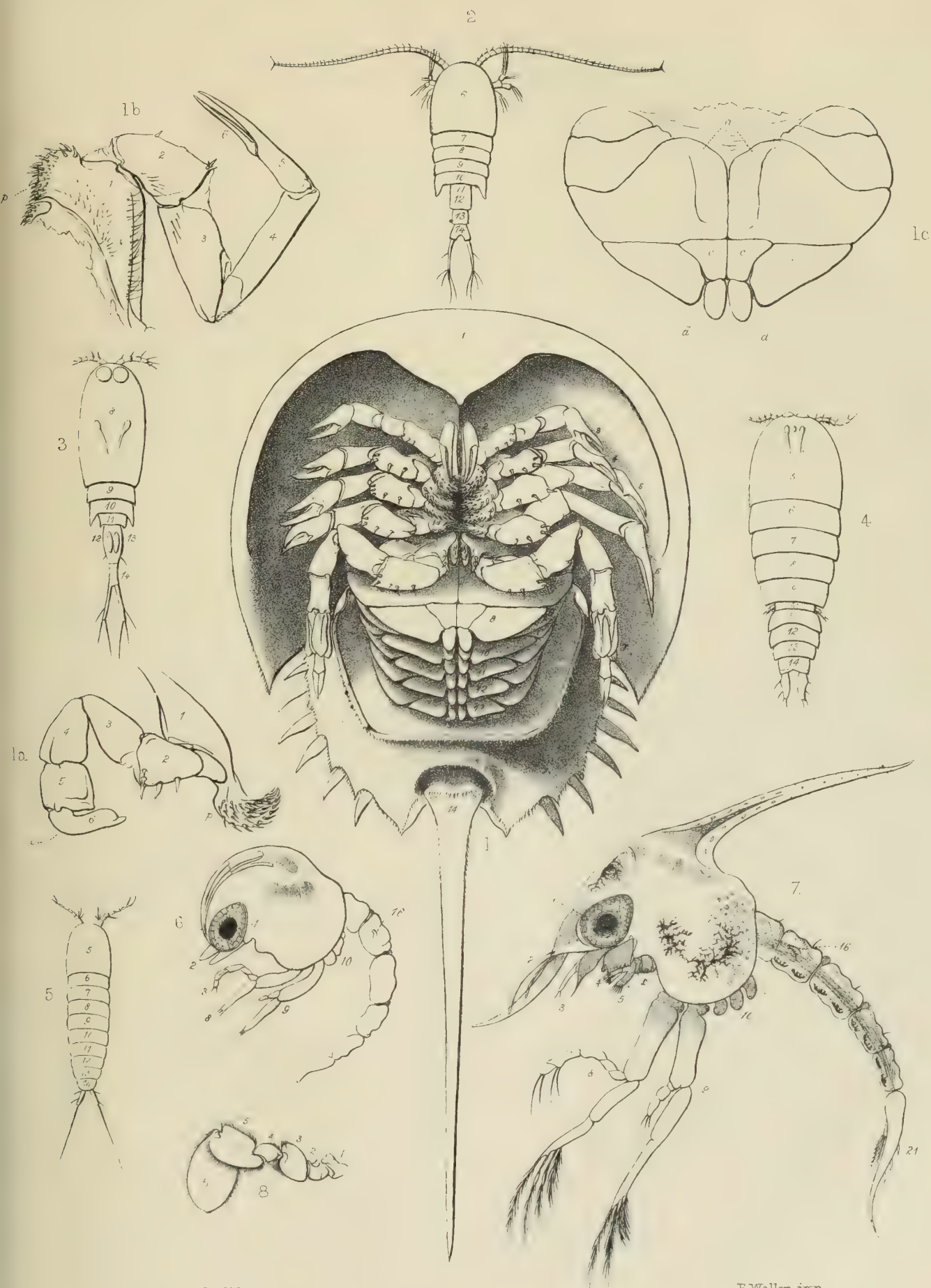
PLATE IX.

ILLUSTRATIONS FROM RECENT CRUSTACEA.

FIG.

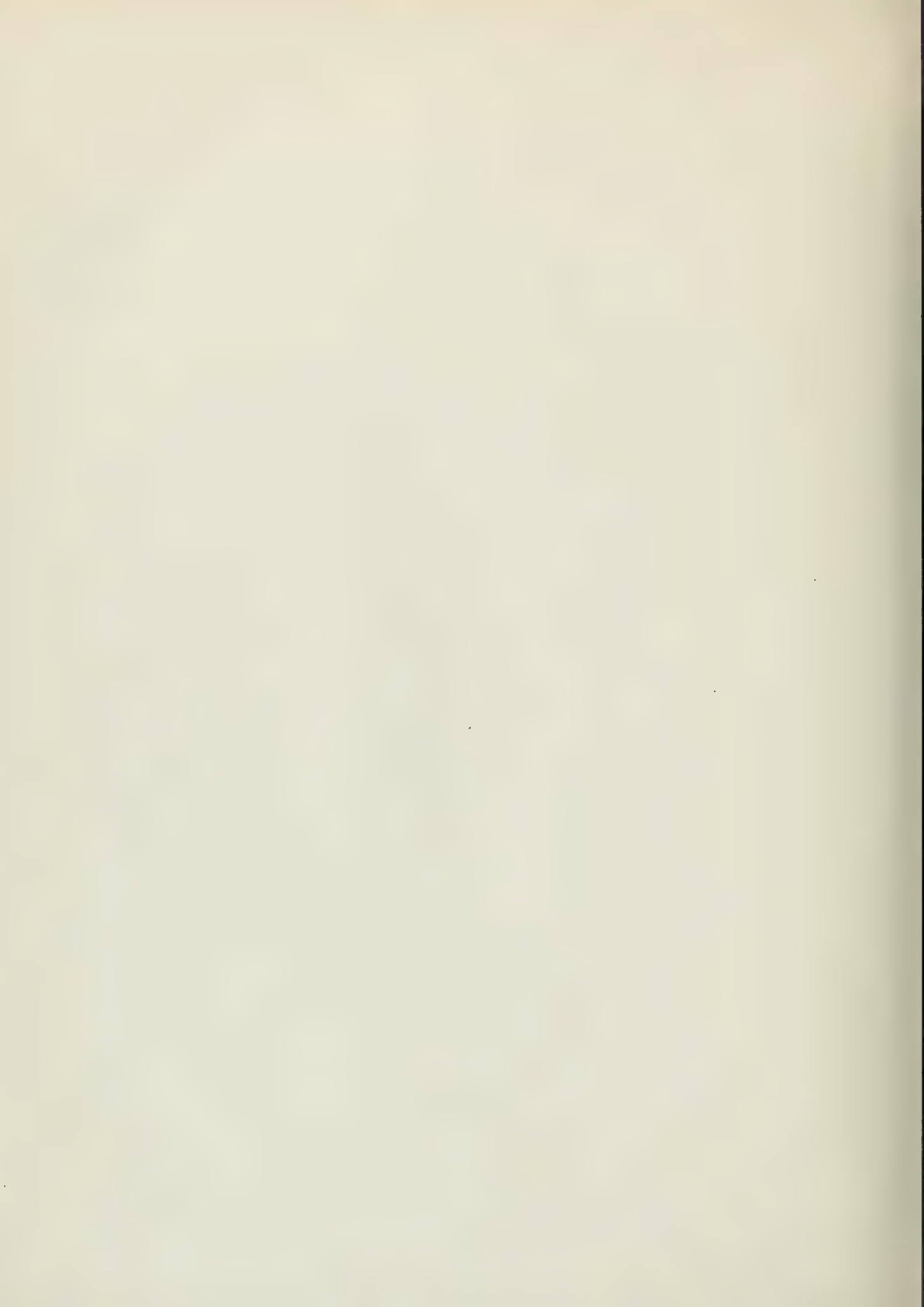
1. Under side of *Limulus polyphæmus*, ♀, from eastern shores of North America. One third natural size. Drawn from a dried specimen.

<ol style="list-style-type: none"> 1. The cephalic shield bearing the sessile eyes upon its upper surface. (The eyes, of course, cannot be seen in this view.) 2. Inner or first antennæ or antennules. 3. Second antennæ. 4. Mandibles. 	<ol style="list-style-type: none"> 5. First maxillæ. 6. Second maxillæ. 7. Maxillipeds. 8. Operculum (covering reproductive organs). 9—13. Branchial plates. 14. Telson.
--	--
 - 1 a. Modified antenna of male *Limulus polyphæmus*.
 1. Basal joint, with its palpus, *p*.
 - 1 b. A detached maxilla of same, showing the palpus, *p*.
 - 1 c. The operculum of *Limulus polyphæmus*, detached. The position of the ovaries is indicated by the dotted lines at *a*; *d, d*, detached articulated appendages, which in *Pterygotus* are welded together and form one coalesced median appendage, but remain bilobed at their extremity in *Eurypterus*.
 2. *Calanus curtus*, Dana, ♀, 'United States Exploring Expedition,' *Crustacea—Cyclopoidea*, vol. xiv, part ii, p. 1059, Atlas, plate lxxii, fig. 10. Sooloo Sea, west of Panay, and Straits of Banca, east of Sumatra.
 3. *Corycæus crassiusculus*, Dana, ♀, 'United States Exploring Expedition,' *Crustacea—Cyclopoidea*, part ii, vol. xiv, p. 1214, Atlas, plate lxxxv, fig. 7. Soloo Sea, west of the Island of Panay.
 1. *Sapphirina ovato-lanceolata*, ♀, Dana, 'United States Exploring Expedition,' *Crustacea—Cyclopoidea*, part ii, vol. xiv, p. 1251, Atlas, plate lxxxvii, fig. 15. Atlantic, off the harbour of Rio Janeiro, lat. 23° S.; long., 41° West.
 5. *Canthocamptus linearis*, ♀, Dana, 'United States Exploring Expedition,' *Crustacea—Cyclopoidea*, part ii, vol. xiv, p. 1188, Atlas, plate lxxxiii, fig. 9 a. From the sea, among the Feejee Islands.
 6. Larva, or *Zoëa*, of *Carcinus Mænas*, Penn., immediately as it quits the ovum.
 7. Larva, or *Zoëa* of ditto, after the first moult.
- Figs. 6 and 7 are copied from Mr. C. Spence Bate's paper on the "Development of Decapod Crustacea," Phil. Trans., 1858, p. 589, plate xl, figs. A and B.
- | | |
|--|--|
| <ol style="list-style-type: none"> 1. The eye. 2. The anterior antenna. 3. Posterior antenna. 4. Mandibles. 5. Anterior maxilla. 6. Posterior maxilla. | <ol style="list-style-type: none"> 8. Anterior gnathopoda. 9. Posterior gnathopoda. 10. Rudiments of pereopoda, or walking-legs. 16. Indications of sexual character? 21. Telson. |
|--|--|
8. Swimming-foot of *Polybius Henslowi*.



E. Fielding del et lith.

F. Waller imp



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LONDON:

MDCCCLXVI.

A MONOGRAPH
OF THE
BRITISH FOSSIL BRACHIOPODA.

PART VII. NO. I.
CONTAINING
PAGES 1—88; PLATES I—XII.

THE SILURIAN BRACHIOPODA.

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ROYAL ACADEMIES OF BELGIUM AND OF BAVARIA; SOCIÉTÉ ROYALE HOLLANDAISE DES SCIENCES, HARLEM;
ROYAL SOCIETY OF LIÈGE; ACADEMY OF ST. LOUIS; AMERICAN PHILOSOPHICAL SOCIETY,
PHILADELPHIA; ZOOLOGICAL SOCIETY OF VIENNA; PALÆONTOGRAPHICAL SOCIETY
OF BELGIUM, ETC

WITH
OBSERVATIONS
ON THE
CLASSIFICATION OF THE SILURIAN ROCKS:

BY
SIR RODERICK IMPEY MURCHISON, BART.,
K.C.B., D.C.L., M.A., F.R.S., F.G.S.,
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COPENHAGEN, STOCKHOLM, BRUSSELS, MUNICH, HOLLAND,
TURIN, ETC.

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1866.

PRINTED BY

J. E. ADLARD, BARTHOLOMEW CLOSE.

BRITISH

SILURIAN BRACHIOPODA.

PRELIMINARY OBSERVATIONS.

WE now conclude our series of Monographs by treating of the Brachiopoda of the Upper and Lower Silurian strata; including therein all that vast series of deposits which, commencing at the base of the "Lingula-flags," extend to the uppermost bed of the "Ludlow Series." This important subject has attracted the serious attention of many distinguished geologists as well as palæontologists; and at my request Sir Roderick Murchison has kindly written, as an Introduction to the present Monograph (p. 19), a concise account of his classification of the Silurian rocks, which will enable the reader better to understand the distribution in time and space of the many species we shall have to describe.

It is well known to every geologist and palæontologist both at home and abroad, that prior to the publication of that truly classical and splendid work, 'The Silurian System,' in 1839, but little attention had been given in Great Britain to the fossils of the Lower Palæozoic period, and but few of the species had been correctly described and illustrated. Not so, however, upon the Continent, where a certain number of the beautifully preserved Swedish, Russian, and other Silurian forms, had for many years previous to the appearance of Sir R. Murchison's celebrated work attracted the keen attention of Linnæus, and afterwards of others, who, in several works to be named in the sequel, had both figured and described a considerable number of Brachiopoda, of which a certain proportion were subsequently found to be identical with those so abundantly spread in the Silurian deposits of this country, as well as in those of many other regions. But in no instance had any foreign naturalist indicated the exact place in the geological series occupied by these ancient remains. In England prior to the publication of 'The Silurian System' very few of the Brachiopoda of that extended period had been

described or illustrated; and indeed it is chiefly in James Sowerby's 'Mineral Conchology of Great Britain' for the years 1813, 1822, and 1823, and in a paper by the same author, published in 'The Transactions of the Linnean Society' for 1815, that some seven Silurian forms of Brachiopoda were for the first time correctly illustrated.¹

During several years prior to 1839, Professor Sedgwick and Sir R. Murchison had devoted much time and labour to the study of the Lower Palæozoic rocks, the one in North Wales, the other in the English and Welsh counties once occupied by the ancient Silures.² From these districts Sir R. Murchison had obtained an immense assemblage of fossils, which, with the exception of the Trilobites, described by himself, he wisely placed for description in the hands of the most competent palæontologists in England. These fossils were consequently stratigraphically arranged, described, and illustrated on the principle laid down by W. Smith, in his memorable work, 'Strata identified by Organic Remains.' The Brachiopoda, which are the only fossils we require here to refer to, were therefore entrusted to Mr. J. de C. Sowerby, who was not only enabled to identify a certain number of our British Silurian forms with those already described by Continental authors, but also made us acquainted with a large number of other species which had not been described up to that period. As part of the results of this examination, we may mention the publication of a "Stratigraphical List" in the 'Sil. Syst.,' as well as short descriptions and excellent figures of about one hundred species of Brachiopoda, distributed in the various geological groups or divisions established and described in the same work by Sir R. Murchison; and indeed, so great was the renown and success of the 'Silurian System,' that its classification was adopted not only in Great Britain, but upon the Continent and in America. It also stimulated further researches in the same direction in various parts of the world; so that the Lower Palæozoic rocks and fossils, which prior to 1839 were so imperfectly understood, are now as well known as any of those belonging to the other and higher sedimentary deposits, forming part of the earth's crust.

We will first of all therefore very briefly allude to the most important works in connection with British Silurian Brachiopoda that have appeared subsequently to the publication of 'The Silurian System.'

In 1843 a few Irish species were figured and described by General Portlock, in his

- ¹ *Terebratula obtusa*, Sow. = *Meristella tumida*, Dal. sp.
- *sinuata*, Sow. = *Orthis biloba*, Linn. sp.
- *Wilsoni*, Sow. = *Rhynchonella Wilsoni*, Sow. sp.
- *affinis*, Sow. = *Atrypa reticularis*, Linn. sp.
- Productus depressus*, Sow. = *Strophomena depressa*, Sow. sp.
- Pentamerus Knightii*, Sow. } = The same.
- *Aylesfordii*, Sow. }
- *lævis*, Sow. = *Pentamerus oblongus*, Sow.

² The reader will find in the 'Proceedings' and 'Journal of the Geol. Society' many important memoirs by Sir R. Murchison, the Rev. A. Sedgwick, and others, on the structure and arrangement of the Lower Palæozoic rocks.

‘Report on the Geology of the County of Londonderry, and of parts of Tyrone and Fermanagh.’

In 1846, Prof. M'Coy, in his work, ‘A Synopsis of the Silurian Fossils of Ireland,’ described some ninety species, and of these he figured thirty-three; but this work, as well as those already mentioned and those to be hereafter referred to, will require considerable revision as far as the determination or identification of the species is concerned; for, as science progresses, our knowledge becomes extended and improved, and we are consequently better able to discover and appreciate those characters which separate one species from another.

In 1847-48, in the ‘London Geological Journal,’ and in the ‘Bulletin de la Société Géologique de France,’ I described and figured some seventy-eight of our British Upper Silurian species, which I had myself in a great measure collected in some of Murchison’s typical Silurian localities.

In 1848, in the second volume of the ‘Memoirs of the Geological Survey of Great Britain,’ Prof. Phillips and Mr. Salter described and illustrated a small number of Silurian Brachiopoda.

In 1852, in the second fasciculus of his important work on ‘British Palæozoic Fossils,’ Prof. M'Coy described in great minuteness one hundred and eighteen species or varieties of Lower Palæozoic Brachiopoda; but of these he figured only twenty-five. It is much to be regretted, that a larger number of the fossils had not been illustrated, for a good figure is very often more valuable than the most elaborate description; and especially so, when forms vary so slightly one from another that it is at times hardly possible to adequately express with words small differences which the figure at once conveys to the eye of the experienced observer.

In 1854, in his revised ‘Catalogue of British Fossils,’ Prof. Morris enumerates some one hundred and seventy species or varieties; and in the last edition of ‘Siluria,’ published in 1859, Mr. Salter furnishes us with a list of one hundred and seventy-seven species of Brachiopoda, which he distributes in the various stratigraphical groups or divisions adopted by Sir R. Murchison in this his last-named very important work. In this edition are likewise added, in the shape of woodcuts, figures of several species of Brachiopoda which had not been discovered at the time the original ‘Silurian System’ was being printed. We must also notice that in ‘The Geologist’ for 1859, Prof. Morris published a list of British Silurian Fossils, including Brachiopoda, “Stratigraphically and Zoologically arranged, with a Reference to a Figure of each Species.” To this paper is also appended a long list of books and memoirs relating to Silurian and Cambrian rocks and fossils.

In 1866, in the third volume of the ‘Memoirs of the Geological Survey,’ Mr. Salter describes and figures several species of Brachiopoda, in the “Appendix” to Prof. Ramsay’s “Geology of North Wales.”

Moreover, a few species of British Silurian Brachiopoda have been referred to in various

other geological works; and descriptions and figures of some new species by Profs. M'Coy and Morris, Mr. Salter, Mr. D. Sharpe, Dr. Holl, myself, and others, occur principally in the 'Quarterly Journal of the Geological Society,' 'Bulletin Soc. Géol. de France,' and in the 'Annals and Magazine of Natural History;' but these will be referred to more in detail in the sequel. Some Scottish Silurian Brachiopoda have likewise been described and illustrated by Mr. Salter, in the 'Memoirs of the Geological Survey' for 1861; and in 1865, by Mr. G. C. Haswell, in a little book 'On the Silurian Formation of the Pentland Hills.' Reference to a few Irish Silurian Brachiopoda will also be found in the 'Explanations of the Geological Maps' published by the Geological Survey of Ireland.

We will now briefly mention the principal works published on the Continent and in America, wherein Silurian Brachiopoda have been described and illustrated, and to which we have been obliged to refer during the preparation of the present Monograph.

SWEDEN.

LINNÆUS, as already stated, appears to have been the earliest author who described Silurian Brachiopoda, for Bromel and Stobæus only give them a passing notice.

In 1753, in the 'Musæum Tessinianum' (one vol. folio), he enumerates four species of Silurian Brachiopoda; but the figures are not good, and it is consequently difficult to be certain as to the forms to which they belong. Herr Lindström, however, considers *Anomia subglobosa*, p. 88, pl. v, fig. 6, &c., to be equivalent to the *Anomites lacunosus* of Wahlenberg; *Anomia angulis lateralibus dilatatis*, p. 90, pl. v, fig. 7, &c., is supposed, from the description and figure given, to be identical with the species now generally known as *Spirifera sulcata*, but which, according to the rules of priority, should bear the name of *Sp. crispa* given to it by Linnæus in the twelfth edition of his 'Systema.' *Anomia subrotunda*, p. 88, pl. v, fig. 5, is a *Rhynchonella*, but difficult to determine; while *Conchidium biloculare*, p. 90, pl. v, fig. 8, A, B, is certainly what we now call *Pentamerus conchidium*, as the habitat given is Gothland, &c. But it is in the twelfth edition of the celebrated 'Systema Naturæ,' the last published by the eminent Swedish naturalist, that we find the greater number of Silurian Brachiopoda described. This edition, which by universal consent is considered to be the best, was published by Linnæus in three volumes, the first printed at Holmia (Stockholm), 1766, bearing on its title-page "Ed. xii^{ma} reformata." The second volume (named Tomus i, pars ii), printed in 1767, contains his notice of the Silurian Brachiopoda, viz., p. 1152, No. 227, *Anomia pecten* (our *Strophomena pecten*); 230, *A. reticularis* (= *Atrypa reticularis*); 231, *A. plicatella*; 232, *A. crispa* (= *Sp. sulcata*); 233, *A. lacunosa* (= *Rhynchonella Wilsoni*, Sow. ?); 240, *A. biloba* (= *Orthis biloba*). Again, it is to Tomus iii, p. 164, printed in 1768, that Wahlenberg refers when mentioning *Anomites novem-striatus*.

Before (for the present) dismissing Linnæus' labours, we must refer to Sylvanus Hanley's 'Ipsa Linnæi Conchylia,' published in 1855, containing his own, the late Mr.

Daniel Sharpe's, Mr. Salter's, and my own observations on the examination we made of Linnæus' original types, now in the possession of the Linnean Society of London; for, as is well known, Linnæus' private collection, his manuscripts, and three interleaved copies of the 'Systema Naturæ,' were long ago transmitted to England. "The original specimens, where large enough, had been inscribed by Linnæus, either with their names or with numerals corresponding to their position in his 'Systema;' the smaller ones had been deposited in tin boxes, marked in a like manner; oftentimes, indeed, the numerals were written on both shells and boxes." But I shall in the sequel have to again refer to the Linnean species, and consequently need not now enlarge upon the subject.

WILHELM HISINGER is the next Swede to whom we would refer. In the "Minerographisk Anmärkning af öfver Gotland," in the 'Kongliga Vetenskaps-Akademiens Handlingar' ("Mineralogical Notes on the Isle of Gothland," in the 'Transactions of the Swedish Royal Academy of Sciences in Stockholm'), at p. 285, he enumerates six species of Brachiopoda under the name of *Anomia*, viz., *A. pecten*, *A. plicatella*, *A. lacunosa*; but his other three so-called *Anomiæ*,—*A. farcta*, *A. gryphus*, and *A. hystera*, would not, according to Linnæus' original specimens, be Silurian forms (see Hanley's 'Ipsa Linnæi Conchylia'). The 'Kongl. Vet.-Ak. Handl.,' 1802 and 1804, contain his mineralogical descriptions of the Isle of Oeland and of the Province of Dalecarlia without any notice of Silurian fossils. In 1825, in his 'Description of some Silurian Fossils from Humlenas, in the district of Calmar,' he mentions *A. pecten*. In 1826 in a 'Treatise on the Geology of the Island of Gothland,' p. 311, the same author enumerates eighteen "Terebratulæ," and for the first time gives figures of his new species *Terebratula crispa* (not of Linnæus), *T. bidentata*, *T. cardiospermiformis* (= *Orthis biloba*). In 1828, in the fourth volume of his 'Anteckningar uti Physik och Geognosi under resor uti Sverige och Norrige' (= 'Annotations in Physics and Geognosy during travels in Sweden and Norway'), and which is also called 'Bedrag till Sveriges Geognosi' ('Contributions towards the Geology of Sweden'), he gives figures, without descriptions, of the following species, *Leptæna euglypha*, Dal., *Cyrtia trapezoidales*, Hisinger, *Gypidia conchidium*, *Delthyris cardiospermiformis*, His., *Delth. crispa*, His., *Atrypa prunum*, Dal., *Terebratula cuneata*, Dal., *T. bidentata*, His. In 1831, in the fifth volume of 'Anteckningar, &c.,' p. 105, he describes the Lower Silurian *Atrypa dorsata* with figure (? *Orthis deformata*); at p. 117, &c., are enumerated thirty-three species of Upper Silurian Brachiopoda of Gothland, but which had almost all been already described by Dalman, in 1827. There are, nevertheless, the following new forms—*Orthis pusilla* (= *Spirigerina pusilla*, Lindst., or *Atrypa disparialis*, Hall); *Delthyris sulcata*, His. (= *Anomia crispa*, Linnæus); *Delthyris? pusio*, His.; *Atrypa reticularis*, var. β , *alata*, *Atr. aspera*, Schlotheim, being by Hisinger considered only as a variety of *Atr. reticularis*; *Atr. tumidula*, His. In his 'Esquisse d'un Tableau des Pétrifications de la Suède,' a list of the already described species is given; and in vol. vi of 'Anteckningar,' p. 8, he briefly describes *Orthis argentea* and *Atrypa nitens*.

from the Clayslate (Lower Silurian of Dalecarlia). In 1837 appeared also the 'Lethæa Suecica,' wherein are described twenty-four Upper Silurian species, and eight common to the Upper and Lower Silurian Formations, viz., *Leptæna rugosa*, *L. euglypha*, β , *transversalis*, *Orthis pecten*, *O. elegantula*, *Atrypa reticularis*, *Terebratula plicatella*, *T. marginalis*, and eighteen Lower Silurian only, forming a total of fifty Silurian species: of course what Hisinger considered species are in some cases now differently viewed. There is nothing new in the 'Supplementum Secundum' to 'Lethæa Suecica,' published in 1840; but in the 'Lethæa Suecica; Supplementi Secundi continuatio,' published in 1841, p. 4, pl. xli, fig. 3, *a, b*, *Cardium multisulcatum*, His., is given, but this is a synonym of *Pentamerus liratus*, Sow. In 1840, volume seventh, and last, of 'Anteckningar,' p. 62, contains a list of thirty-three (or rather thirty-two) species of Gothland Silurian Brachiopoda; at p. 57, a similar list of six species from Oeland: from Ostrogothia eleven species; p. 71, from Westrogothia six species; and from Dalecarlia ten species of Brachiopoda.

A great portion of the above details connected with Swedish Silurian Brachiopoda has been kindly forwarded to me by my able friend Herr G. Lindström, who has himself devoted so much time and care to the study of Swedish fossils, as well as to those of Great Britain; and I consider it desirable to give these details, that the reader should be in possession of the sources from which so many of our own British Silurian names have been taken; for in no part of the world with which I am acquainted do we find assembled more species identical with our own.

GEORG WAHLENBERG. In his "Petrificata telluris Suecanæ," published in the 'Acta Societatis Regiæ Scientiarum Upsalensis,' vol. viii, p. 63, et seq., 1821, are described five Lower Silurian species of Brachiopoda, five common to Lower and Upper Silurian, and three Upper Silurian only; total 13 sp.; and all are mentioned in the 'Lethæa' of Hisinger, excepting *Anomites terebratulinus*; no figures are given.

J. W. DALMAN. In the 'Kongl. Vetenskaps-Academiens Handlingar' for 1827 (Stockholm, 1828), we find Dalman's important memoir "Uppställning och Beskrifning af de i Sverige funne Terebratuliter" ("Descriptions of the Terebratulites found in Sweden" in the 'Transactions of the Royal Academy of Sciences of Stockholm'). In the introduction he describes his new genera *Leptæna*, *Orthis*, *Delthyris*, *Gypidia*, *Cyrtia*, and *Atrypa*, as well as fifty-nine species (exclusive of *Crania* which he did not consider to be a Brachiopod); of these, sixteen are Cretaceous, and forty-three Silurian. They are accompanied by six plates, subsequently copied by Hisinger in his 'Lethæa.' In no other work of Dalman do we find reference to Silurian Brachiopoda; his memoirs published in the years 1824 and 1826 relating only to Trilobites.

N. P. ANGELIN. "Musæum Palæontologicum Suecicum in ordinem redigit, nec non

venale præbit, etc.," is the title of a collection that Prof. Angelin arranged and offered for sale to subscribers. He was then a student of the University of Lund. The specimens are arranged in wooden boxes with printed labels; and on the cover of the parts of Prof. Kroeyer's 'Nat. Hist. Review,' for 1838, there is published a list of the fifty species, and it was from this "Musæum" that some names of Silurian species of Brachiopoda have been adopted by Herr G. Lindström.

E. DE VERNEUIL. In 1847, I took over to Paris a large series of British Upper Silurian Brachiopoda that I might compare them with species from other countries that had been collected by M. de Verneuil during his many travels. This led my eminent friend to examine along with myself a large number of Swedish Silurian Brachiopoda; and in vol. v., 2nd series, of the 'Bulletin de la Société Géologique de France,' p. 339—347, 1848, will be found a list of forty-nine Swedish Silurian Brachiopoda, of which I figured some of the new species in pl. iv of the same work.

In 1851, Hr. SJÖGREN in a geological description of the Isle of Oeland, in the 'Proceedings of the Royal Academy of Sciences of Stockholm,' gives a list of eleven species of Brachiopoda, of which one seems new. In the published account of his travels through Sweden in 1858, Herr F. SCHMIDT, of St. Petersburg, mentions the names of the already described Swedish species.

We now arrive at the last and certainly the most important work that has been hitherto published on Swedish Silurian Brachiopoda, and to which we shall often have to refer, namely, that by my distinguished friend Herr G. LINDSTRÖM, viz., "Bidrag till Känne domen om Gotland Brachiopoder" published in the 'Proceedings of the Royal Acad. of Sciences,' Stockholm, for 1860. In this memoir are described eighty-eight species and seven varieties, and several of the new forms are well figured in two accompanying plates; but of these the author now considers his *Cyrtina multisulcata* to be *Pentamerus liratus*, and his *Pent. rotundus* to be only a variety of *P. linguiferus*; *Strophomena antiquata*, and *Atrypa depressa*, have since been added to the Gothland list, making the known forms amount to ninety species, of which the larger number are found also in England. In his Introduction, the author has endeavoured to establish that the Upper Silurian Formation of Gothland can really be divided into three groups, equivalent with the English Silurian groups, as had already been demonstrated in 1845 by Murchison, and later by Fredr. Schmidt. In his memoir, Lindström enumerates the Brachiopoda which are characteristic of each of these divisions; for instance, *Pent. liratus* in the oldest deposit, and so forth, as may be seen in the synoptical table appended to the paper, page 390. In this author's last memoir, entitled, "Observations on the Zoantharia Rugosa," published in 1865, he has endeavoured to demonstrate that neither the Silurian nor Devonian species of *Calceola* belong to the Brachiopoda.

Prof. Lovén and Herr Walmstedt, do not appear to have published any thing on Swedish Brachiopoda; but Lindström has adopted two or three of their MS. names.

DENMARK AND NORWAY.

Nothing that I am aware of has been published on the Brachiopoda in Denmark. In Norway, Dr. T. Kjerulf, the Director of the Geological Survey, has in his various papers given some scanty lists of the fossils; no new species being described.

RUSSIA

Is exceedingly rich both in Upper and Lower Silurian Brachiopoda; and many of its species are identical with our own. These fossils had also attracted the attention of Pander and Eichwald prior to the publication of the 'Silurian System;' but since then they have been more extensively studied by several native and foreign palæontologists, who in various important works have described and beautifully illustrated the larger number of their at present known species.

M. E. D'EICHWALD in several works describes and figures many Silurian Brachiopoda. For instance, in his 'Zoologia Specialis,' vol. i, published in 1829; in his memoir, "Ueber das Silurische Schichten-System von Esthland," published in the 'Journal für Natur-und-Keilkunde, herausgegeben von der Kaiserl. Medico-Chirurg. Academie zu St.-Petersburg,' 1841; in the 'Bulletin de la Soc. Imp. des Nat. de Moscou,' for 1864; as well as in the 'Skizze von Podolie,' 1830: but it is in his "Die Urwelt Russlands," 1840-42-43, and in the "Lethæa Rossica, Ancienne Période," 1861, that we find the larger number of Russian Silurian Brachiopoda figured and described.

In 1830, Dr. CHRISTIAN H. PANDER published at his own expense a quarto volume, with thirty plates, 'Beiträge zu Geognosie der Russischen Reichs,' in which many species of Brachiopoda are both described and illustrated: herein the author proposes many new genera; but of these *Porambonites* alone has been generally adopted. Subsequently, in the third volume of the Academy of Sciences of St. Petersburg, for October, 1860, Dr. Pander describes two new genera of Silurian Brachiopoda, which he names *Helmersenia* and *Keyserlingia*.

BARON L. VON BUCH has also alluded to some species of Russian Silurian Brachiopoda in the fifteenth volume of the 'Archiv für Mineralogie, Geognosie, Bergbau und Hutterkünde,' Berlin, 1840, as well as in his 'Ueber Delthyris, oder Spirifer und Orthis,' Berlin, 1837.

In 1845 appeared the celebrated work, 'Russia and the Ural Mountains,' by Sir R. Murchison, M. de Verneuil, and Count A. von Keyserling; and in the second volume,

the two last-named palæontologists give us descriptions, lists, and beautiful illustrations of all the Russian Silurian Brachiopoda known at the time of the publication of their labours. Count Keyserling, in a subsequent work, 'Reise in das Petschora-Land,' 1846, adds some figures and descriptions of Russian Brachiopoda to those already made known in 1845.

Dr. S. KUTORGA has likewise contributed to our knowledge of Russian Silurian Brachiopoda, and his memoirs in the 'Dritter Beitrag zur Paläontologie Russlands' for 1846, and his paper in the 'Verhandlungen der Kaiserlichen Mineralogischen Gesellschaft, für 1847,' may be particularly noticed, as it contains admirable figures of some new genera, and especially of *Siphonotreta*, *Obolus*, and *Aulonotreta*.

Herr FREDERICH SCHMIDT's excellent work, "Untersuchungen über die Silurische Formation von Ehstland, Nord-Livland, und Oesel," published in the 'Archiv für die Naturkunde Liv-, Ehst- und Kurlands, 1st series, vol. ii, Dorpat, p. 1—248, 1858, contains lists and descriptions of many Silurian Brachiopoda, of which a certain number appear to be identical with those found in Sweden and Great Britain.

Herr M. VON GRÜNEWALDT has also published descriptions and figures of Russian Silurian Brachiopoda in a memoir, "Ueber die Verst. der Silurischen Kalksteine von Bogosslowsk," &c., in the 7th vol. 'Des Mémoires des Savants Etrangers de St.-Petersbourg,' 1854, and in his memoir, 'Beiträge zur Kenntniss der Sediment. Gebirgsformationen in den Berghauptmannschaften Ekaterinburg, Slataust und Kushvina,' 4to, 1860.

K. E. v. BAER and Gr. v. HELMERSEN's 'Beiträge zur Kenntniss des Russ. Reichs und der angränzenden Lander Asiens' contains several articles by D'EICHWALD on Brachiopoda. This work has continued to appear during the last twenty-five years. Silurian Brachiopoda have also been described in the 'Bulletin de la Société des Naturalistes de Moscou,' in the Transactions of the Academy of Sciences of St. Petersburg, and in the 'Verhandlungen der Kaiserl. Min. Gesellschaft zu St.-Petersburg' for 1842—1863, &c.

MAXIMILIAN HERZOG VON LEUCHTENBERG, 'Beschreibung einiger Thierreste der Urwelt aus den Silurischen Kalkschichten von Sarskoje.' Selo, 1843.

BELGIUM.

But little has been published on Belgian Silurian Brachiopoda; we may, however, mention the following papers:

T. GOSSELET, 'Mémoire sur les Terrain primaire de la Belgique,' &c., 8vo, Paris, 1860; 'Bulletin de la Soc. Géol. de France,' 2nd ser., vol. xviii, 1860; 'Bulletin de l'Académie de Belgique,' 2nd ser. vol. xv.

C. MALAISE, "De l'Age des Phyllades fossilifères de Grand Manil près de Grimlaux;" 'Bull. de l'Acad. de Belgique,' 2nd ser., vol. xiii, 1862; and 'Sur l'existence en Belgique de nouveaux gîtes fossilifères à Faune Silurienne,' ib., vol. xviii, 1865.

GERMANY.

If we except Barrande, there are but few persons who have published on the Silurian Brachiopoda of Germany, although there are various German works wherein Silurian Brachiopoda have been generally treated. Amongst these we may mention the following few:—Two of Leopold von Buch's works have already been noticed under RUSSIA, but a few species are also described in his 'Ueber Terebrateln, mit einem Versuche sie zu classificiren und zu beschreiben,' Eine in der Königl. Akad. der Wissenschaften gelesene Abhandlung, 1834.

H. B. GEINITZ's 'Die Verst. der Grauwackenformation in Sachsen und den angränzenden Länder,' &c., Leipzig, 1853. In this work several Silurian species are described, such as *Lingula paralleloides*, *Orthis callactis*, *Chonetes striatella*.

C. GIEBEL, 'Die Silurische Fauna des Unterharzes,' Berlin, 1858. Here we find several of our well-known Upper Silurian Brachiopoda figured and described, such as *Spirifer crispus*, *Sp. spurius*, *Rhynchonella Wilsoni*, *Pentamerus Knightii*, *P. galeatus*, *Leptaena transversalis*, *Discina rugosa*, &c.

F. ROEMER, in the "Lethaea Geognostica, von Bronn und Roemer," Th. ii, Erste Periode, pp. 291—397, 1852, describes a few new species of Silurian Brachiopoda, as well as in his "Beiträge zur geologischen Kenntniss des Nordwestlichen Harzgebirges" (in Dunker and Meyer's 'Palæontographica' for 1850 and 1852).

In another work by F. ROEMER, 'Die Silurische Fauna des Westlichen Tennessee,' 4to, Breslau, 1860, a good many species of Silurian Brachiopoda are described and illustrated. He has, moreover, traced the extension of the Wenlock fauna from the Island of Gothland as far as the Mississippi in America, the fauna of the Silurian strata in Western Tennessee being of the same type, whereas that of the corresponding strata in Bohemia is entirely different from what we find in Gothland. In a memoir, 'Die Fossile Fauna Ober-Silurischen Diluvial,' &c., Breslau, 1861, the same author gives figures of Brachiopoda from Silurian erratic blocks occurring in great abundance at Oels, near

Breslau, originally derived from Ebstad, and stated to be of the age of the Llandovery Rocks.

M. BARRANDE'S monograph, "Ueber die Brachiopoden der Silurischen Schichten von Böhmen," published in the 'Naturwissenschaftlichen Abhandlungen, Wien,' 1847 and 1848, is by far the most important work on German Silurian Brachiopoda; it is illustrated by eighteen quarto plates; but Mr. Barrande informs me that he has under preparation another similar but more extensive monograph, wherein some two hundred Bohemian species of Silurian Brachiopoda will be described and fully illustrated. I look forward with deep interest to the publication of the last-mentioned work; for, coming from the pen of so eminent and able a palæontologist, this monograph will be in every respect most valuable.

Among the German authors who have published lists, figures, and descriptions of some Silurian Brachiopoda, I should have mentioned various works of E. VON SCHLOTHEIM, the most remarkable of which is 'Die Petrefactenkunde,' published at Gotha, in 1820. BRONN, in his 'Index Palæontologicus,' published in 1848, gives us a general list, with references of all the Silurian Brachiopoda then known to him. Some interesting descriptions and figures will also be found in FR. A. QUENSTEDT'S 'Handbuch der Petrefactenkunde,' 1851.

FRANCE

Is not rich in Silurian Brachiopoda, and consequently not much has been written there upon the subject. We may, however, mention two papers by MARIE ROUAULT, on some species found in Brittany and Normandy; they are published in the seventh and eighth volumes, second series, of the 'Bulletin de la Soc. Géol. de France.' In D'ORBIGNY'S 'Prodrome' (1849) will also be found a catalogue of Silurian Brachiopoda compiled from then existing materials.

SPAIN AND PORTUGAL.

We are chiefly indebted to M. DE VERNEUIL for the little we know concerning Spanish Silurian Brachiopoda, and this will be found in the twelfth volume, second series, 1855, of the 'Bulletin de la Société Géologique de France.' With reference to Portuguese species, a paper was published by Mr. D. SHARPE, in the ninth volume of the 'Quarterly Journal of the Geol. Soc. of London.'

ITALY.

No Silurian Brachiopoda have, as far as I am aware, been hitherto found in Italy, but Prof. MENEGHINI, in his admirable work on the 'Paléontologie de l'Ile de Sardaigne,' Turin, 1857, describes and beautifully illustrates some sixteen species of Silurian Brachiopoda that had been discovered in that Italian island by General Albert de la Marmora.

INDIA.

A number of Silurian Brachiopoda from the Niti Pass, in the Northern Himalaya, have been described and figured by Messrs. SALTER and H. F. BLANFORD (Calcutta, 1865); these specimens were collected by Col. R. Strachey (see 'Quart. Journ. Geol. Soc.,' vol. vii, p. 292).

AMERICA.

Both Canada and the United States are exceedingly rich in genera and species of Silurian Brachiopoda, and these have been well described and figured by many palæontologists.

CANADA AND NOVA SCOTIA.—We are especially indebted to Mr. E. BILLINGS, Palæontologist to the Geological Survey of Canada, for many very valuable descriptions and figures of Canadian Silurian Brachiopoda. These will be found recorded in publications of the Geological Survey of that country,—'Palæozoic Fossils,' vol. i, 1861-65; in the 'Reports' for 1856-58; as well as in various numbers of the 'Canadian Naturalist and Geologist' for 1859-60; also in the 'American Journal of Science' 1863, &c. Mr. Billings has proposed a few new genera amongst the Lower Palæozoic Brachiopoda.

Some species from the Silurian Rocks of Nova Scotia have likewise been described and figured by Prof. J. HALL, in a paper communicated to the Natural History Society of Montreal ('Can. Nat. Geol.'), and afterwards republished in Dr. Dawson's 'Acadian Geology,' 1855.

UNITED STATES.¹—No one in America has devoted so much attention to the many

¹ Rafinesque appears to have been the first person (so far as I know) who published anything on American Silurian Brachiopoda; but, notwithstanding all the inquiries which I have made in conjunction with Prof. Suess, De Koninck, and J. Hall, I have not yet been able to obtain a certain reference to that author's early papers. In the 'Annales des Sciences Physiques,' by Bory-Saint-Vincent, Van Mons, &c., p. 232, Brussels, 1820, will be found a memoir entitled "Prodrome d'une Monographie des Turbinolies fossiles du Kentucky," in which it is stated, while enumerating the objects collected in America by Rafinesque and Clifford, that several genera, such as Madreporites, Favosites, Encrinites, Terebratula, &c., are so numerous in species that it would not be possible for the author to arrive at a speedy determination of their species and characters, since their European congeners have been so imperfectly sketched out. That, for

beautiful Silurian Brachiopoda that abound in the rocks of that extensive country than Prof. JAMES HALL, State-Geologist; and to his magnificent work, 'Palæontology of New York,' for 1847-52, the reader is particularly directed. The same eminent palæontologist has also devoted many pages of the 'Annual Reports of the Regents of the State of New York Library, &c.' for 1857-65 to the description and illustration of a vast number of new Palæozoic genera and species of Brachiopoda; and to these, as well as his 'Report on the Fourth Geol. District, New York,' 1843, we shall often have occasion to refer.

CONRAD, in the 'Journal of the Acad. of Nat. Sciences of Philadelphia,' vol. viii, 1842 and 1843, and in the 'Annual Geol. Reports, New York,' 1838-40, has described a great many species of Silurian Brachiopoda.

The reader will also find a number of American Silurian Brachiopoda described and figured in the following works; but a more complete list will be given hereafter:

EMMONS, 'Report, Second Geol. District, New York,' 1842-3 and 1859.

VANUXEM, 'Report, Third Geol. District, New York,' 1842-43.

F. DE CASTELNAU, 'Essai sur le Terrain Silurien de l'Amerique du Nord,' 1843.

EATON, 'Geological Text-Book,' 1831. In this work the author has identified some European species, and proposed names for other Brachiopoda.

MATHER, 'Report on the First Geol. District, New York,' 1843.

example, amongst the Terebratulæ they have observed more than sixty species which required to be located in several new genera, such as *Gonotrema*, *Diclisma*, *Pleurinia*, *Stropheria*, *Strophomena*, *Clipsilia*, &c., besides the true genera *Productus* and *Terebratula*, &c. It is, however, probable that some of these American Silurian genera and species had been described somewhere by Rafinesque prior to 1820; but where and when we do not know. I would, therefore, feel obliged to any person who might be able to afford me correct information upon the matter. Can any of them have been published in Rafinesque's 'Travels and Discoveries in the West,' Pittsburg, 1818, and announced in 'Silliman's Journal' for 1818, vol. i, p. 311, as well as in the 'Giorn. Encycl. Sicil.,' or in the same author's 'Atlantic Journal'? These books are rare, and I have not been able to obtain access to them. In 1825 Blainville, to whom Rafinesque's former works must have been known, both describes and figures the American genus *Strophomena*; but the oldest diagnosis written by Rafinesque himself with which we are acquainted dates 1831, and may be found in his 'Continuation of a Monograph of the Bivalve Shells of the Ohio River, and other rivers of the Western States,' which was published separately at Philadelphia, in October, 1831, and subsequently in Chenu's 'Biblioth. Conchyl.' Other genera, which can hardly be made out, will be found recorded in p. 381 of the 'Bull. Soc. Géol. de Fr.' for 1839, as well as in the 'Journal de Physique' for 1839, vol. lxxxviii, p. 427; and most likely also in C. S. Rafinesque's 'Enumeration and Account of some Remarkable Natural Objects in the Cabinet of Philadelphia,' 1831. None of the American palæontologists with whom I have communicated upon the subject appear to be able to afford us any more definite information upon the subject; it is, however, probable that the first notice of American Silurian Brachiopoda will be found to date back not later than 1819 or 1820.

SAY has given several MS. names (adopted by Hall) to specimens in the collection of the Acad. Nat. Sciences, Philadelphia.

DR. D. DALE OWEN, 'Reports of a Geol. Survey of Wisconsin, Iowa, and Minnesota,' 1852, and 'Annual Geol. Rep., Wisconsin,' 1860.

F. ROEMER (see Russia and Germany).

BIGSBY, "On the Palæozoic Basin of the State of New York," in the 'Quarterly Journal of the Geol. Soc.' for years 1858, 1859.

DE VERNEUIL, 'Bulletin Soc. Géol. de France,' 2nd series, vol. iv, 1847; and vol. v, 1848.

PROF. ROGERS, 'Geology of the State of Pennsylvania,' 1858, contains a good deal in connection with the Silurian Brachiopoda.

DR. B. F. SHUMARD has published an account of several American Silurian Brachiopoda from the State of Texas, in the 'Trans. Acad. Nat. Sci. St. Louis,' vol. i, 1860; also in the 'Am. Journ. Sci.' for 1861. I am, moreover, informed that he finds, by looking over his list, the names of more than 350 species of North American Silurian Brachiopoda; but of these a large number will have to be classed as synonyms.

DR. F. V. HAYDEN and F. B. MEEK give an account of some Silurian Brachiopoda, of the age of the Potsdam Sandstone, from near the Black Hills and other localities along the eastern side of the Rocky Mountains, in the 'Am. Journ. Sci.,' Jan., 1862, also in 'Acad. Sci. Philad.,' Dec., 1861; see likewise the same palæontologists' 'Palæontology of the Upper Missouri,' published by the Smithsonian Institution, April, 1865, &c., &c.

Notwithstanding all this labour, much, indeed, still remains to be achieved before all these British and foreign so-termed species can be satisfactorily illustrated, revised, and referred to their proper genera, for the number of synonyms and of incorrectly identified forms is considerable: but such a state of things is not, however, surprising; for our accurate knowledge of these fossils is not yet so much advanced as to enable the palæontologist to grapple with so immensely large and difficult a subject, or to admit of his always correctly discriminating or defining a certain number of these still imperfectly known so-called species. This desideratum will, no doubt, be attained in time; and the publication of a general monograph, embracing the species from every country, will doubtlessly help, though the work cannot be fully and successfully accomplished until after many more years of active and intelligent research, aided by fresh discoveries and more ample materials. It would, indeed, be presumptuous were I, however much may have been my labours and efforts, to pretend that in the present Monograph I could work out even our British forms in a completely satisfactory manner, and therefore all I now hope to do is to offer to the student the results of our combined knowledge upon the subject I have to treat; and this, I trust, may prove to be of some utility, since we

do not yet possess any book in which all our British Silurian Brachiopoda have been assembled, described, and adequately illustrated.

Many are the genera into which the Silurian Brachiopoda have been distributed ; but have all these so-termed genera and subgenera been as yet sufficiently studied ? Are all their characters understood, and can we locate in them with certainty all our presumed species ? These are questions which may be fairly put, and we will endeavour to answer them in the sequel ; but it may at once be observed that, although the larger number of forms have, I think, been correctly identified, there are some of whose genus and species we cannot feel certain, and which will require to be left in doubt, until the discovery of more ample material enable the palæontologist to raise the veil under which they are still of necessity partially shrouded.

It is well known to geologists and palæontologists that a large proportion of the Lower Silurian Brachiopoda of Great Britain, as well as of other countries, occur only in the condition of internal casts and of external impressions ; the shell itself, which originally occupied the space left free between the external and internal impressions, having totally disappeared ; and therefore, if by the means of softened gutta-percha we take a mould of the external impression as well as of the interior cast, we are able to reproduce the shell itself, both exterior and interior, as completely and as sharply as if we had just taken the valves from the sea. This I have done to a very considerable extent,—indeed in every instance where the operation was possible ; and I am consequently enabled to figure a large number of these Lower Silurian forms in a way that has not been hitherto attempted. Indeed, these internal and external casts admit in many cases the possibility of a more complete and satisfactory study of the species than we are at times able to effect with some of the Upper Silurian beautifully preserved bivalve specimens, but of which the interior is concealed from our view by the hard matrix filling the shell. The value, therefore, of gutta-percha as an auxiliary in the study of Silurian Brachiopoda is considerable, and is destined to render still further service in the same direction.

British Silurian Brachiopoda had, indeed, prior to the publication of the present work, received a considerable amount of study ; but although one hundred and seventy-seven species are named in the most recently published catalogues, the whole subject required considerable revision, for a large proportion of these forms do not appear to have been sufficiently studied or illustrated ; while others are undoubted synonyms, and the identification of a few was exceedingly uncertain. The very considerable researches I have been compelled to make for the present Monograph will, I hope, remove doubt with reference to some of these, and also enable me to add to our list several new forms or species not hitherto recorded as British.

Thanks to the kind assistance of many friends, I have had the great advantage of possessing for a time under my own roof, and of being able to study and draw my illustrations from, the best and largest series of specimens ever assembled. To Sir R. Murchison, Prof. Huxley, and Mr. Etheridge, I am greatly indebted for the very kind and

liberal manner with which they afforded me all the information I required; as well as for the loan of the large and exceedingly important national collection of Silurian Brachiopoda that had been assembled during the progress and labours of the Geological Survey of Great Britain, and which I consider to be the most extensive and most valuable series, as a single collection, ever brought together under one roof. From this collection I have now figured a very great number of specimens; it contains also the types of many species that had been previously described and illustrated by Portlock, Phillips, Salter, myself, and others.

My best thanks are likewise due to the Council of the Geological Society, who, besides awarding to me their much valued Wollaston Medal, have, in the most liberal manner, placed their Silurian collections at my command for the present Monograph. The Society's Museum contains the very valuable original types described and illustrated in the 'Silurian System,' as well as a series of specimens collected by the late Mr. Daniel Sharpe; and from these two sources I have figured many specimens. My thanks also are due to the officers of the Geological Department of the British Museum for the free access I have had to their specimens; but although our National Museum contains the important Upper Silurian collection made by Mr. Gray, of Hagley, it is still very deficient in species and specimens from our Lower Silurian Rocks,—which deficiency will, I trust, with time be made good. The next to which I must particularly refer is the very extensive collection assembled with much care by the Rev. Adam Sedgwick, during his very important study of the Welsh Lower Palæozoic deposits, and subsequently deposited by him in the Woodwardian Museum of Cambridge. This series of fossils has been minutely described and partly figured by Prof. M'Coy in his work on 'British Palæozoic Fossils.' This Museum also possesses Mr. Fletcher's valuable series of Upper Silurian fossils. I am, therefore, much indebted to Prof. Sedgwick, as well as to Mr. H. Seeley, for having been able to consult its specimens.

My thanks are also due to the Directors of several provincial Museums, such as those of Ludlow, Dudley, Worcester, &c., as well as to the following gentlemen, who have not only kindly lent me their specimens, but have also afforded me much valuable information:—Mr. J. W. Salter (London); Mr. D. C. Davies (Oswestry); Prof. J. Morris (London); Mr. G. H. Morton (Liverpool); Mr. W. Fletcher (Stourbridge); Mr. J. Gray (Hagley); Mr. W. Prosser (Lancaster); Mr. W. Walton (Bath); the late Mr. J. Mushen (Birmingham); Mr. E. Wood (Richmond, Yorkshire); Mr. S. W. Williams (Rhayaden); Mr. R. Lightbody (Ludlow); Mr. W. Vicary (Exeter); Mr. R. H. Valpy (Newbury); Mr. Griffith Davies (London); Dr. H. B. Holl (Worcester); Mr. L. P. Capewell (Dudley); Mr. W. Lewis (London); Mr. R. Tate (London); Mr. Winwood (Devonshire); Mr. H. Wyatt-Edgell (London); Mr. W. Cocking (Ludlow); Mr. Marston (Ludlow); Mr. W. Pengelly (Torquay); Mrs. Branwell (Brighton); Prof. Harkness (Cork); the Rev. J. D. Latouche; the Rev. P. B. Brodie (Rowington); Mr. G. Sharman (London); Mr. T. J. Shedden (Walsall); Prof. T. Rupert Jones (Sandhurst); the Rev. T. Wiltshire (London); &c.

I have also to acknowledge much valuable assistance from my Scottish friends, who have spared no trouble while assembling for my use all that their collections and localities would afford. From Messrs. J. Thompson, J. Young, J. Armstrong, and Mr. and Mrs. Gray, of Glasgow, I have received a large number of Ayrshire Silurian specimens. The Pentland Silurian series has been kindly contributed by Messrs. G. C. Haswell, D. J. Brown, and J. Henderson, of Edinburgh; and I am, moreover, indebted to Mr. A. Geikie and Dr. Young, of the Geological Survey of Great Britain, for much valuable information with reference to Scottish Silurian geology and localities; and from Mr. Slimon, of Lesmahago, I have received useful information and the Silurian species of his district.

From Ireland I have also been able to study a large number of Silurian species; and my thanks are particularly due to Mr. J. B. Jukes, Director of the Geological Survey of Ireland, as well as to Mr. W. H. Baily, Palæontologist of the same Survey, for the kind manner with which they forwarded to Brighton, for my inspection and study, the large and very valuable series of Silurian Brachiopoda that has been collected during the Geological Survey of Ireland; and I have also to thank Sir R. Griffith, Bart., and Mr. R. Byron, for the loan of the original series of Silurian Brachiopoda described and figured by Prof. M'Coy in his 'Synopsis of the Silurian Fossils of Ireland.' I am likewise indebted to Mr. J. Wright, of Cork, for many specimens obtained at the Chair of Kildare and other Irish localities.

My thanks are likewise due to Mr. E. de Verneuil, Prof. L. de Koninck, Dr. Volborth, M. Barrande, Prof. F. Roemer, Herr G. Lindström, Herr F. Schmidt, Capt. V. de Möller, Prof. Hall, Mr. Billings, Sigr. Meneghini, and to several other friends, for much valuable information in connection with foreign Silurian species.

I may, in conclusion, here remark that, besides the very large number of original illustrations that will be found in this Monograph, I have, wherever such appeared desirable, reproduced the original figures, as well as part of the descriptions, published by the first describer of the species, so that no doubt may exist with reference to the identification.

INTRODUCTION.

OBSERVATIONS

ON THE

CLASSIFICATION OF THE SILURIAN ROCKS;

BEING

AN INTRODUCTION TO THE DESCRIPTION OF THE BRACHIOPODA OF THAT SYSTEM,
BY T. DAVIDSON, ESQ., F.R.S.

BY

SIR RODERICK I. MURCHISON, BART., K.C.B., D.C.L., F.R.S.,
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THIRTY-ONE years ago I proposed to geologists that the term "Silurian" should be applied to a very extensive group of the lower sedimentary rocks which rise from beneath all those deposits the order and contents of which had then been systematically described. Having led the way in classifying these old deposits, by showing their true order of succession, and the fossil remains of each subordinate formation, I have lived to enjoy the satisfaction of seeing the name "Silurian" adopted in all parts of the world to which Geological Science has been extended. But, just as the proverb is true, "that Rome was not built in a day," so the Silurian Classification, of which I launched the first outline in 1835, was but the prototype of that system into which it had to be developed by much labour in the field and closet. In 1838, I had, indeed, completed my main work upon the subject, with maps, sections, and a description of all the organic remains then known, under the title of 'The Silurian System,' founded on researches in eleven counties of England and Wales, or what I called the "Silurian Region," because the famous Caractacus or Caradoc had been the British king of the tracts, occupied by the Silures, wherein the clearest evidences of the order of the strata were exhibited.¹ But

¹ In the description of the fossils I was chiefly indebted to Mr. James de C. Sowerby and Mr. William Lonsdale; and I should fail to do justice to my own feelings, and to the reputation of a first-rate geologist, if I did not state, that, in the composition of the work, I was greatly aided by the last mentioned of these valued friends. In the later work 'Siluria,' the able palæontologist Mr. J. W. Salter was my main assistant.

still, after a labour of seven years, I found that much remained to be done, in showing to what extent the classification ought to be applied to other parts of the British Isles, and also to foreign countries. After surveys of parts of the Continent, and particularly by a first examination of the rocks of this age in Russia (1841), I could not but perceive that formations in all respects equivalent to those I had described in my limited Silurian region had a vastly wide Continental range. I was also led to suspect that large mountainous tracts in North and South Wales, to which Professor Sedgwick applied the term of "Cambrian," and which, like himself, I at first thought rose up from beneath, and were older than my typical deposits, were, in fact, nothing more than extensive undulations of the typical Silurian strata in a more crystalline condition. Even in 1841, that good geologist, the late Dr. Fitton, then President of the Geological Society, in reviewing the 'Silurian System' and its published fossils, declared that the division of the "Cambrian" from the Silurian Rocks, as regarded their imbedded fossils, was "merely conventional, and matter of temporary convenience."¹ Now, at that time no "Cambrian" fossils had been described; but, when they were scrutinised by palæontologists, they were found to be nearly altogether well-known Silurian published types. Thus, of necessity, the fossiliferous part of the undescribed "Cambrian" fell palæontologically into the then established Silurian system. Subsequently, indeed, stratigraphical evidences were produced, showing that the slaty rocks of Bala and Snowdon (which had been called "Cambrian" before their fossils were known) were not older, as had been supposed, than the Caradoc Lower Silurian formation, but were simply repetitions of the same strata with an altered lithological aspect, and thus the question was completely disposed of.

In subsequent years, the accurate surveys of Sir Henry Delabèche, Professor Ramsay, and other Government Geologists, demonstrated, that there existed in Wales no other representative of the Cambrian Rocks than the equivalent of the Longmynd Mountain in Salop, which I had shown to underlie the Silurian Stiper Stones; and hence, as proved by fossils, as well as by order of superposition, the Cambrian system of Britain became much reduced in dimensions.

Having already, in 1842, satisfied myself of the truth of this inference, by an examination of North Wales, in company with my Russian associate, Count A. von Keyserling, I lost no time in announcing this view to my countrymen,² and it was adopted by von Buch and Humboldt, in Germany; by de Verneuil, in France; and, indeed, generally at home and on the continent of Europe.

The same extended application of my Silurian classification had been already made by the geologists of the United States, and particularly by Mr. James Hall, who synchronized all the ancient American deposits from the Potsdam Sandstone at the base to the lowest limit of true Devonian Rocks as belonging to the Silurian system. Sir

¹ 'Edinburgh Review,' April, 1841.

² See my Anniversary Address to the Geological Society in 1842, 'Proceedings Geol. Society,' vol. iii, p. 640.

Charles Lyell, in his 'Travels in North America,' and in other earlier works, adopted the same classification.

In Germany, indeed, the system was also successfully developed in the same sense by M. Barrande, in his classical work the 'Bassin Silurien de Bohême;' and in British North America it has since been most thoroughly worked out on exactly the same basis, both as to its fossil contents, and its relations to inferior and superior rocks, by that sound geologist Sir William Logan.

Desirous of showing the generalisation to which the Silurian System had thus been extended to various countries, including its range over Russia and Scandinavia, as demonstrated by de Verneuil, von Keyserling, and myself,¹ I next published the first edition of the work called 'Siluria,' wherein I not only indicated the main features of the Silurian rocks in various countries, but also greatly augmented the figures and lists of characteristic fossils, many of which were ably described by Mr. Salter. In that work the relations of all the Palæozoic Rocks to each other, whether in Britain, or in the various foreign countries which had been sufficiently explored, were correlated and compared, including the Uppermost Palæozoic deposits, to which, during my journeys in Russia, I had, with the approbation of my coadjutors, assigned the name of "Permian."

As years rolled on, and as new discoveries were made, it became necessary to issue a new edition of 'Siluria' (1859). This volume was much enriched by descriptions of many additional fossils by Mr. Salter, by more defined sub-divisions of the various Silurian formations, resulting from the labours of the Geologists of the Government Survey, particularly Mr. Aveline, by which the formation termed the Llandovery Rocks was interpolated as a sort of middle group between the Caradoc Formation below and the Wenlock Strata above. This book was also specially marked by containing the result of my own researches in the North-west of Scotland, wherein I established, for the first time in the British Isles, the existence of stratified rocks of higher antiquity than any to which the names of Cambrian and Lower Silurian had been applied, for they were seen to underlie all such deposits, including limestones, with very ancient Lower Silurian types. These rocks I at first termed "Fundamental Gneiss," and their position was illustrated in the coloured diagrammatic frontispiece of the work; but, on being satisfied, from their order of infra-position to all the Palæozoic Rocks then known, that they were the precise equivalents of the Laurentian System of British North America (so named by Logan), I, of course, adopted the name given to them by my eminent cotemporary. At that time, nothing organic had been discovered in the Laurentian Rocks of North America; and the only fossil as yet discovered in the rocks to which the term Cambrian had been restricted was the *Oldhamia*, an organism of doubtful affinity, which has been placed respectively with the Polyzoa, the Hydroid Zoophytes, and even with the Calcareous Corallines and other Algæ. The two

¹ See 'Russia and the Ural Mountains,' 2 vols. 4to, Murray, 1845, with maps, numerous sections, and plates of fossils.

British species may even represent two different genera; the *Oldhamia antiqua* of Forbes being the *Murchisonites antiquus* of Göppert.¹ Subsequently another organism, called *Eozoön Canadense*, classed with the Foraminifera, and allied to *Tinoporus* of the Nummuline Group, has been discovered in the Lower Laurentian Rocks of North America, which, as far as all researches go, constitute the fundamental strata in the crust of the globe.

Wedded to no theory, and guided solely by an appeal to facts, I have not passed the better half of my long life in exploring the foundation-stones of the earth without being led to recognise, in the successive works of Nature, the clearest proofs of creative power, as manifested by the appearance in each succeeding deposit of animals specially adapted to the conditions of each geological period.

Thus, in those very fundamental strata, wherein igneously formed or molten matter is associated with the once muddy or sandy layers accumulated in the seas of that pristine period, now in the state of gneiss, geologists who, up to the time of the recent discovery, believed these rocks to be azoic, or void of traces of life, now know that nothing distinct has been discovered save a low form of Protozoon, or Foraminifer of the class Rhizopoda.² In the next overlying group, or Cambrian, we find, besides the Zoophyte *Oldhamia*, the remains of Annelids or Sea-worms, of the genera called *Histioderma*, *Chondrites*, &c., with the single doubtful Crustacean termed *Palæopyge*. In the Cambrian, therefore, a slight advance only in the forms of life is apparent; but no sooner do we proceed upwards into the accumulations of detrital matter which were next added to the crust of the earth, *i. e.*, the Lower Silurian, than we meet with marked additions in the presence of both Mollusca (especially Brachiopoda) and Crustacea, associated with much more complex Zoophytes, or Corals, than those of the older rocks. These, with certain Cephalopoda, Heteropoda, Pteropoda, and Annelida, constitute the entire Fauna of the Lower Silurian Rocks, in which the closest researches of the last quarter of a century have failed to detect any remains of Fishes, or the lowest class of Vertebrata. For in the median or Llandovery Group, and even throughout two thirds of the Upper Silurian Rocks, notwithstanding the great increase of other marine animals, still we find no remains of Fishes, and it is only on reaching the Upper Ludlow Rocks, and specially in those beds which pass upwards into the Devonian System, that the relics of Fishes have been found. These were described by me in my earliest work, in which it was announced that the Fishes of that epoch first “appeared before naturalists *as the most ancient beings of their class*,”³ and such they still remain. In the forty years which have elapsed since these words were printed, they have never been gainsaid; and hence those authors eminent as they are, who have laid it down in their tables, that Fishes appeared at the same time as the invertebrate orders of animals, are directly in antagonism to the results

¹ Flora Sil. Dev. Unter-Kohl., pl. 34, f. 1-2.

² This is under the supposition that, with Dr. Carpenter and others, we reject the validity of the efforts which have been recently made to show that the so-called *Eozoön* is not an animal but a mineral substance.

³ Silurian System, p. 605: see also note.

of the universal researches of geologists.¹ It follows, therefore, that the Silurian deposits, as a whole, were formed in an incalculably long "invertebrate" period.

The general succession of life presented to us by fossils is the following:—In the oldest sedimentary deposits, Protozoans, Zoophytes, and Annelids only occur; in the next epoch, Mollusca, especially Brachiopoda, with Annelida, Crustacea, and Echinodermata. These continued to be associated during enormously long periods of time, and were the exclusive tenants of the sea. In the following period Fishes appeared, and they were, in another era, succeeded by Reptiles; and then, after another very lengthened time, insectivorous marsupial Mammals, of small dimensions, appeared.

In dwelling, however, on the Silurian Rocks only, the palæontologist may next be reminded of a few data respecting their geographical extension, physical characters, and order, as they rise to the surface in the British Isles, in a very large portion of the whole area of the United Kingdom. Referring, in the first instance, to the original Silurian Region proper, or that wherein the system was established, it will be recollected that I showed how these rocks occur largely in the following eleven counties, viz., Salop, Hereford, Radnor, Montgomery, Brecon, Carmarthen, Pembroke, Monmouth, Gloucester, Worcester, and Stafford. In the north-west of England, *i. e.*, in Lancashire, Cumberland, and Westmoreland, the system has since been seen to be very largely developed, and strikingly so in the Lake-country, between Kirby Lonsdale in the south and Skiddaw in the north; it having recently been proved, by their imbedded fossils, that the slates of the last-mentioned mountain, or the oldest rocks in Cumberland, are simply equivalent of the Lower Llandeilo Rocks of the Silurian Region.² Altogether they occupy an area of about 7600 square miles in England and Wales. Then again, in Scotland, with some slight exceptions of overlying deposits, Silurian Rocks prevail in the whole of the southern counties, from the Solway Firth on the west and from Berwick on the east, to the great Carboniferous trough that extends from Fife and Edinburgh to Glasgow and Ayr. These are chiefly of Lower Silurian age; but every here and there, as seen in the Pentland Hills, near the Scottish metropolis, they exhibit transitions into Middle and Upper Silurian, the latter being most completely developed near Lesmahago, in Lanarkshire. If to this vast area, throughout which fossils are found at intervals, we add the Highland counties, or those north of the Tay and the Clyde, in which rocks of Lower Silurian age have undergone great metamorphism, and exhibit fossils at two or three rare localities only, it may be stated, that the strata of this great system occupy the surface in Scotland to the extent of about 18,420 square miles.

In Ireland also, though their exact boundaries have not yet been precisely defined, it

¹ See the works of all the American geologists, and of the Canadian Survey; Barrande's 'Bassin Silurien de Bohême'; 'Russia in Europe and the Ural Mountains'; Angelin and Swedish authors; and the recently published work and map of Kjerulf as respects Norway.

² See Harkness's Memoir, 'Quart. Journ. Geol. Soc.,' vol. xix, page 113, and vol. xxi, p. 235: Mr. H. Nicholson discovered most of the fossils therein named.

may be said, that, looking to their diffusion in the counties of Dublin, Wicklow, Wexford, Kerry, Cork, Limerick, Galway, and Donegal, they must occupy a large portion of the subsoil of that green and drift-covered island, or nearly 7000 square miles. Thus, as regards the British Isles, the Silurian Rocks rise to the surface over nearly 33,000 square miles.

Viewed as they occur, not only in Britain, but in distant parts of the globe, the Silurian Rocks must be chiefly regarded as deposits of calcareous and argillaceous mud and sand, accumulated in seas of different and varying depths. So much does the purely argillaceous character prevail in the typical districts of the original Silurian Region, that at one time I even thought of applying to the group the term of "Mudstone Series." But when I ascertained that the same deposits which are purely argillaceous in large tracts alternated in others with limestones and sandstones, and that in Wales they passed into crystalline slates, the use of a geographical term, which should embrace all the stony varieties of the series, became a necessity. Hence the word "Silurian," as simply implying the name of a region in which the true order was first made out. In numerous other regions, as well as in England and Wales, the same alternation of lithological conditions was found to exist. Thus the slightly indurated mud on which St. Petersburg is built was proved to be the equivalent of the Lower Silurian rocks of Britain;¹ whilst the same deposits in the Ural Mountains were found to be highly crystalline schists and slates, the sedimentary sandstones being changed into quartz-rocks.

Looking to these changes of mineral character in the deposits of the same age, it has been found difficult, if not impossible, to assign to each formation or sub-formation of the system a lithological description which would invariably be found to apply. Hence the utter inapplicability of the old mineralogical term "Grauwacké," which had indeed been indiscriminately applied by the earlier German geologists to all the rocks which have since been separated into Cambrian, Lower and Upper Silurian, Devonian, and even Lower Carboniferous Rocks. The following, therefore, is to be taken as a generalised sketch of the stony character of the Silurian Rocks of the British Isles only, and in their ascending order.

The lowest of the Silurian Rocks of Shropshire, the tract wherein their order was first pointed out by myself, is a great mass of dark-coloured schistose shale, or consolidated mud, reposing upon the Cambrian Rocks of the Longmynd Mountain, and dipping under the picturesque ridge of the Stiper Stones; thus constituting the true base of my original system. These shales, or soft schists of finely levigated mud, were next found to be the equivalents in position of the Welsh Lingula-flags; and though in Shropshire they have not as yet been found to contain fossils, yet in Merionethshire in North Wales, and in Pembrokeshire in South Wales, they not merely contain abundance of *Lingulæ*—which thenceforward occur throughout the Silurian System, but also Trilobitic Crustacea (*Paradoxides*, *Olenus*, *Agnostus*, and *Microdiscus*), and *Hymenocaris*; and most of these, in North America, Germany, Russia, and Sweden, characterise the

¹ See 'Russia and the Ural Mountains,' by Murchison, de Verneuil, and Keyserling, vol. i, p. 24.

lowest beds of the series termed Silurian by American, German, French, Russian, Swedish, Norwegian, and Spanish authors.

This band, the "Primordial Zone" of Barrande, is manifestly the natural base of the Silurian or earliest great Trilobitic and Brachiopodous series. But, whilst the strata passing beneath the Stiper Stones of Shropshire are merely consolidated mudstones, they are in North Wales hard slaty rocks.

The next overlying strata are known in Wales as the Tremadoc Slates. The relations as well as the fossils of these deposits, whether in North or South Wales (Pembrokeshire), have been ably worked out of late years by Mr. Salter; whilst their general range and characters are delineated by Professor Ramsay, in his classical and valuable Monograph of the North-Welsh Rocks, just published,¹ and in which the general classification of which I am now tracing the outline is adopted throughout.

This band, the Lower Llandeilo of my classification (see 'Siluria,' 2nd ed., *passim*), is everywhere rich in fossils, being characterised by *Lingulæ*, *Dictyonemæ*, Crustacea (Trilobites), and Heteropoda. The Trilobites specially characteristic of this zone are, *Psilocephalus innotatus*, *Niobe Homfrayi*, *Asaphus Homfrayi*, *Ogygia scutatrix*, and *Conocoryphe*, associated with *Dictyonema* (*Graptopora*) *sociale*, *Conularia*, and *Theca*.

The associated sandstone strata have been altered in the Stiper Stones of Shropshire into quartzites and hard schists, and exhibit on their western flank a peculiar group of fossils, viz., *Trinucleus Murchisoni*, *Æglina binodosa*, *Lingula plumbea*, *Redonia* (*Cucullella*) *complanata*, *Didymograpsus geminus*, *Orthis alata*, and *Orthoceras Avelinii*.

Ascending in the series, the chief or upper part of the Llandeilo Formation is essentially argillaceous—mere mudstones in one district, calcareous flagstones in another, and slates in a third; and is characterised by numerous Brachiopoda, particularly by Orthidæ, Rhynchonellidæ, and Lingulidæ, but specially also by Trilobites (*Ogygia Buchii*, *Asaphus tyrannus*, *Calymene Murchisoni*, *Dionide atra*, *Æglina caliginosa*, *Trinucleus Murchisoni*), and several genera of Graptolites, which first make their appearance in the Lower Llandeilo. The last-named Zoophytes highly typify, indeed, the whole Silurian system, except the "Zone Primordiale," and are never found in younger rocks. A few Echinodermata also occur in the Lower Llandeilo Beds; and here we have also the first well-determined evidence of the occurrence of the Lamellibranchiata, characterised by *Palæarca*, *Ribeiria*, *Redonia*, &c. The Llandeilo Formation, with occasional limestones, occurs not only in Siluria and Wales, but also in Cumberland, where, as above stated, the Skiddaw Slates, its representative, form the lowest band in that slaty region.

The next ascending formation, the Caradoc, is in Shropshire, to a great extent, a sandstone, associated with some impure shelly limestones and shale; but in North Wales, after certain folds, it occupies the Bala country, and becomes a hard and slaty rock, some-

¹ 'Memoirs of the Geological Survey of Great Britain,' vol. iii; "On the Geology of North Wales."

what arenaceous, with courses of impure limestone. Its fossils, particularly the Brachiopoda, are so characteristic, that, whether you meet with them on the slopes of Caer Caradoc, where they were first described, or at Bala and Snowdon, they leave no doubt whatever of the age of the rock to which they belong. For example, *Siphonotreta micula*, *Orthis alata*, *O. vespertilio*, and *O. Actoniæ*, with *Strophomena expansa*, *Leptæna sericea*, and *L. tenuicincta* occur abundantly; added to which, other and important forms of life come in, such as *Glyptocrinus*, *Sphæronites*, and *Pleurocystites*, among the true Crinoids, with *Palæaster*, &c., in the group of the Asteriadæ. *Homalonotus bisulcatus*, *Trinucleus seticornis*, *Cybele verrucosa*, and *Asaphus Powisii*, illustrate a rich group of Trilobites; whilst numerous Cephalopods of the genera *Cyrtoceras*, *Orthoceras*, and *Lituites*, occur, all equally important, as determining and fixing the age and position of these Caradoc or Bala Rocks.

The rocks hitherto enumerated constitute the Lower Silurian division of my classification, in which, as before remarked, no trace of a vertebrated animal has been discovered. These rocks are largely associated with masses of igneous origin, both cotemporaneous and intrusive; and to comprehend their relations, as well as their various dislocations and overlaps, the Map of the Government Survey, and particularly the recently published work of Professor Ramsay above mentioned, must be consulted. The total thickness of these rocks has been estimated at about 17,000 feet.

In the earliest years, when I was preparing the first Silurian Classification, I simply divided the system into Lower and Upper Silurian rocks; but in the sequel, and by close examination of the organic remains, it was found that some of the strata, having more or less of an arenaceous character, which formed the summit of the Lower Silurian rocks of my earliest tabular arrangement, were in reality characterised by many new species, and deserved a separate name. These strata I named "Llandovery Rocks," from their full development near the town of that name in South Wales. Again, in other tracts, particularly at May Hill, in Gloucestershire, some fossils were found to pass upwards into younger beds, which, in their turn, were surrounded by the true base of my original "Upper Silurian" Rocks. Hence, in the last edition of 'Siluria' (1859), I adopted the term Llandovery Rocks," to mark this intermediate group, the lowest beds of which graduate down by their fossils into the Caradoc Sandstone, and the highest of which are connected with the Woolhope Beds, or base of the Wenlock Formation.

The Brachiopods drawn and described by Mr. Davidson unambiguously prove that these Llandovery strata form a central link, thus uniting more closely together the Lower and Upper Silurian Rocks.

As illustrative of the evidence and correctness of this view, and the stratigraphical value of the Brachiopoda as a group of fossils to be used for this purpose, I merely offer the names of a few genera and species, noticing first those forms which do not occur below the Llandovery rocks. There are *Pentamerus oblongus*, *Rhynchonella decemplexata*, *Rh. navicula*, *Rh. obtusiplicata*, &c., *Lingula crumena*, *Athyris* (*Meristella*) *tumida*,

Strophomena arenacea, *St. imbrex*, *Leptaena Grayi*, *Chonetes lata*, *Atrypa hemisphærica*, *Spirifer elevatus*, &c. The Lamellibranchiata and Gasteropoda contain genera and species hitherto unknown; added to which, *Illænopsis Thomsoni*, *Illænus Barriensis*, *Encrinurus punctatus*, *Proetus Stokesii*, and *Phacops Downingiæ*, among the Trilobites, offer other features of distinction, and tend still more to elucidate the clear succession in time of these Llandovery Beds; such forms being here found for the first time in the ascending series of deposits.

When we mount into the true Upper Silurian Series, as constituting the Wenlock and Ludlow Formations, we find ourselves generally in rocks of the same argillaceous character as in the Lower Silurian, but usually in a much less hardened and altered state; so much so, that in many tracts where limestones do not prevail, the beds are little more than slightly indurated, finely levigated mudstones, which have not undergone the action of metamorphism that has affected them in other localities with a slaty cleavage, and thus altered their aspect. But, in Great Britain, the phenomena of unaltered strata is very much confined to the typical Silurian region; for in parts of North Wales some of the Wenlock Shales have been converted into roofing slates. This also holds good in many other parts of the world. Indeed, in Devonshire and Cornwall, and in the Rhenish provinces, strata of the Devonian age are equally slaty.

As might be expected, the great abundance of the Upper Silurian fossils occurs in the zones of subordinate limestone; and hence the Woolhope or Lower Wenlock Limestone, and the Wenlock or Dudley Limestone, are the centres, particularly the last mentioned, wherein the reliquæ of the marine animals of that period most abound. In these beds the great mass of the Silurian Brachiopoda figured and described by Mr. Davidson occur, associated with many genera of Crustacea common to the Lower Silurian, some being entirely new forms; Corals and Echinodermata, as well as the Cephalopoda, having also much increased. Amongst the Corals (Cœlenterata) many new genera now appear, comprising *Acervularia*, *Aulacophyllum*, *Cœnites*, *Omphyma*, *Cystiphyllum*, &c. The Echinodermata seemed to have reached their maximum development in the seas of this age; and, although too numerous to mention here, I must allude to the Cystidæ, *Caryocystites*, *Prunocystites*, *Pseudocrinites*, &c., a remarkable group, stratigraphically and zoologically defined by the late Leopold von Buch and the late Professor Edward Forbes. These Crinoids are associated in the same beds with the lily-shaped Encrinites, *Crotalocrinus*, *Cyathocrinus*, *Dimerocrinus*, *Ichthyocrinus*, and *Taxocrinus*, &c.; also with those Cephalopoda characterised by numerous species of the group of the Orthoceratidæ, many of which assumed gigantic proportions. Yet, amidst this vast profusion and wealth of marine life no trace of a true Fish, I repeat, has hitherto been found in strata of this or the preceding age in any country.

Towards the close of these Silurian strata, as seen near Ludlow, the argillaceous and calcareous beds pass upwards into more sandy and shore-like deposits, and with this lithological change the earliest known Fishes appear (see *Note*, p. 30), and thus

usher us into the first great Ichthyic period, the Devonian or Old Red Sandstone, so well marked by its Fossil Fishes in Russia, Britain, and North America.

No zoological feature in the Upper Silurian rocks is more striking than the great increase and profusion of Cephalopods, many of them of great size, which appear in strata of the age immediately antecedent to the dawn of vertebrated life. A grand illustration of this phenomenon has already appeared in the second volume of the '*Système Silurien de Bohême*,' by M. Barrande, who has already figured and described,—Goniatites, 17 species; Trochoceras, 44 sp.; Nautilus, 7 sp.; Gyroceras, 7 sp.; Hercoceras, 2 sp.; Lituities, 7 sp.; Phragmoceras, 32 sp.; Gomphoceras, 70 sp.; Ascoceras, 15 sp.; in all, 202 species, or distinct varieties, as occurring in the rich Silurian Basin of Prague; and the greater number of them named, as well as figured and described, by Barrande. I learn from my distinguished friend that when his grand and classical work is completed, no less than 3000 species of fossils will have been described from the limited Silurian Basin of Bohemia alone!

It is generally believed, and I embrace the view, that this group of large and straight-chambered Cephalopods preyed upon the numerous lower tribes of marine life during the long Silurian era; and, as relates to Great Britain, it is curious to notice, that with the advent and prevalence of Fishes in the Devonian era, the gigantic Cephalopods diminished in number and in size. From their first appearance to the present day, the numbers of genera and species of Fishes, which are, we know, the most predacious animals of the sea, have gone on increasing, whilst the more voracious and large Cephalopods have become exceedingly rare.

In the progression of life, as above sketched out, the Silurian System is characterised throughout by certain Brachiopods, particularly Lingulidæ, Orthidæ, Pentameri, &c., which everywhere prevail; also by the pennate Zoophyte called Graptolite, which, as before said, has not been found in younger rocks; by Trilobites of certain genera, nearly all of which are peculiar to it; and by Cephalopoda and Echinodermata, of forms never found in any overlying or younger deposit.

Now, in all this immeasurably long series of geological deposits, beginning with the dawn of Molluscan life, the Brachiopods are the most abundant, persistent, and reliable types of life by which geologists recognise the different formations. Hence, it has given me the truest satisfaction, that my eminent friend, Mr. Thomas Davidson, should have at last completed his long labour of love by terminating his description of the Palæozoic Brachiopods of Britain with so skilful and elaborate a delineation and description of all the species of this class known in the Silurian Rocks. Furnished as he has been from many quarters with fossils of the several formations constituting the Silurian System, it was peculiarly gratifying to me, as Director-General of the Geological Survey of the United Kingdom, to place under his examination all the Silurian and other Palæozoic Brachiopods in the cases of the Government Geological Museum in Jermyn Street, illustrating the Survey. It is also important to mention that, having considered the Jermyn Street

Museum to contain the national type collection of Britain, Mr. Davidson has figured, in every instance, those specimens which are most truly characteristic, including also many of the oldest types, collected by myself, and now preserved in the Museum of the Geological Society. He thus affords to the student, and mainly through the assistance of our able Palæontologist, Mr. Etheridge, a ready means of comparing any species he may collect with the fixed species in the geological museum of the nation. Thus, along with other works in the field and the closet, this Monograph, and the beautiful fossil forms found in our own country—all drawn by the hand of Mr. Davidson—will remain as illustrations of the truthfulness of our national geological maps, as prepared after a careful correlation of the order of the strata with their imbedded animal remains.

From his long residence in France, as well as in other parts of Europe, and his intimate acquaintance with the Palæozoic collections of M. de Verneuil and others, whether formed in Europe, America, or elsewhere, Mr. Davidson has happily had advantages which few of his cotemporaries have enjoyed; and when we reflect that the labour of so many years has, on his part, been one of true love of natural history science, all Geologists, feeling how much they owe to him, must unite with me in gratefully recording our sincere obligations. For myself, I cannot sufficiently express the gratitude I feel for the devotion, perseverance, and ability with which Mr. Davidson has fulfilled his great undertaking, thus crowning his many admirable works with a complete Monograph of the oldest known group of Fossil Brachiopods in the crust of the globe.

P.S.—In the preceding pages 24 *et seq.* the prevalent lithological characters only of the typical Silurian rocks of Britain have been given. The pebbly beds and conglomerates which occasionally occur are mentioned in the following table.

Tabular View of the Silurian Strata.

UPPER SILURIAN.	LUDLOW GROUP	Passage-beds, Tile-stones, and Downton Sandstones	{ A series of greenish-grey shales, containing lenticular pockets of hard grey grit; with abundance of Crustacean and Plant remains, <i>Lingula cornea</i> , and Fish fragments. Thin-bedded yellowish sandstones, with Crustacean (<i>Pœcilopod</i>), Plant, and Fish remains, ¹ <i>Lingula cornea</i> ? var. <i>minima</i> (Sow.), <i>Orthoceras</i> , <i>Platyschisma helicites</i> , <i>Modiolopsis</i> , <i>Beyrichia</i> , &c. Loc. Ledbury, Ludlow, Downton, Kington, Lesmahago.
		Upper Ludlow Rock	{ Yellowish, greenish, and grey argillaceous sandy mudstone, with calcareous lenticular and nodular masses, and many species of Brachiopoda, <i>Chonetes lata</i> , <i>Rhynchonella nucula</i> , <i>Discina rugata</i> , <i>Orthis lunata</i> , and <i>O. elegantula</i> , with <i>Orthonota amygdalina</i> , <i>Serpulites longissimus</i> , &c. Loc. Whitcliffe, Ludlow, Malvern, Longhope.
		Aymestry Limestone	{ Grey, pale-yellow, or brown shales, with bands of argillaceous limestone in the upper part, and containing great numbers of <i>Strophomena filosa</i> , <i>St. depressa</i> , <i>Rhynchonella nucula</i> , <i>Rh. navicula</i> , and <i>Lingula Lewisii</i> ; the lower portion also consisting of beds of argillaceous limestone, filled with <i>Pentamerus Knightii</i> , <i>P. galeatus</i> , <i>Strophomena euglypha</i> , <i>Atrypa reticularis</i> , <i>Lingula striata</i> , with <i>Proetus Stokesii</i> , <i>Phacops caudatus</i> , &c. Loc. Whitcliffe, Aymestry, View Edge, Onibury.
		Lower Ludlow Shale	{ Yellowish-grey, hard flaggy and nodular argillaceous shales, with occasional beds of impure limestone, and containing concretionary nodules of fossiliferous blue limestone: the upper portion contains <i>Lingula lata</i> , <i>Graptolites Ludensis</i> , and <i>Cardiola interrupta</i> ; in the middle portion <i>Phragmoceras</i> and <i>Lituites</i> occur; and in the lower <i>Phacops</i> , &c. Loc. Vinnal Hill, Mocktree, Stokes Wood, Onibury.
	WENLOCK GROUP	Wenlock Limestone	{ Argillaceous or semi-crystalline limestone, and lenticular masses of concretionary matter, abounding in organic remains, especially Crinoidea, Cœlenterata, Crustacea, and Brachiopoda; <i>Spirifera plicatella</i> , <i>Sp. elevata</i> , <i>Athyris tumida</i> , <i>Atrypa reticularis</i> , <i>Rhynchonella Stricklandii</i> , <i>Rh. borealis</i> , <i>Rh. Wilsonii</i> , <i>Orthis rustica</i> , <i>Strophomena antiquata</i> , <i>Discina Forbesii</i> , and <i>Obolus Davidsonii</i> , being most typical. Loc. Wenlock Edge, Dudley, Walsall, May Hill, &c.
		Wenlock Shale	{ Hard flaggy beds and thin shales, in places slaty, with occasional beds of sandstone; fossils resembling those above. Loc. Wenlock, Dudley, Walsall, Malvern, Usk, &c.
		Woolhope Beds.	{ Dark-grey, semi-indurated limestone, with much carbonate of lime in veins, and occasional bands of argillaceous nodules, &c., also sandy beds in places; <i>Illænus (Bumastus) Barriensis</i> , <i>Orthis Davidsoni</i> , <i>O. elegantula</i> , var. Loc. Woolhope, Walsall, &c.
		Denbighshire and Tarannon Slates	{ Thin-bedded flaggy sandstones and slaty beds; fossils comparatively rare in places, especially in the gritty beds. Loc. Flintshire, Denbighshire, Tarannon river-banks, &c.
		Upper Llandoverly	{ Grey and yellowish sandstones (occasionally conglomerates), with bands of limestone; rich in organic remains, especially Brachiopoda; <i>Pentamerus oblongus</i> , <i>Rhynchonellæ</i> , <i>Orthides</i> , &c. Loc. May Hill, Shelve, Tortworth, &c.

¹ Lowest zone containing true fossil Fishes.—Adopting the classification I established, that the Silurian system, as a whole, is characterised by Invertebrata only, Mr. D. Page, in his Manual, has included the Lud-

LOWER SILURIAN.

Lower Llandovery.

Hard sandstones, conglomerates, and flaggy shaly beds; the fossils closely allied to those of the Upper Llandovery series; but distinguished by *Pentamerus lens*, and by unconformity.

Caradoc or Bala Rocks.

Shelly sandstones, shales, and slaty beds, with quartzose grits, conglomerates, and occasional limestone or calcareous bands; fossils numerous, especially Echinodermata, Crustacea (Trilobites), Polyzoa, and Brachiopoda; of the last nearly fifty species, including *Orthis Actoniæ* and *O. flabellulum*. Loc. Caradoc, Horderley, Norbury, Bala, Snowdon, Wexford, Kildare.

Llandeilo Flags

Dark-grey flagstones, occasionally calcareous, with black slates containing *Graptolites*, &c. The Llandeilo Flags constitute two groups, Upper and Lower. *Lingulæ*, *Obolellæ*, *Discinæ*, and *Orthidæ* occur in, and characterise this group of rocks, with *Ogygia Buchii*, *Asaphus tyrannus*, and *Trinucleus concentricus*. Loc. Llandeilo, Builth, Shelve district, Cader Idris, &c.

LLANDEILO GROUP.

Lower Llandeilo
or
Tremadoc Slates

Dark-grey and ferruginous slates, sandy shales, and hard bluish flags, with occasional beds of pisolitic iron-ore, much felspathic matter in lines and thin beds; the Lower and Upper Tremadoc Slates contain numerous genera of Trilobites, *Ogygia scutatrix*, *Asaphus Homfrayi*, *Eglinæ*, *Trinucleus*, &c., also Heteropod and Pteropod Mollusca, &c., with Graptolites (*Diplograpsus pristis* and *D. folium*), and *Orthis alata* and *O. testudinaria*. Loc. Stiper Stones, Tremadoc, Portmadoc, Ffestiniog, Dolgelly, Dudreath, &c.

Lingula-flags

A great series of black and dark shales, grey and brown thin slaty flagstones and sandstones, with siliceous grits and quartzites (Stiper Stones); occasionally crowded with fossils, and always having the characteristic *Lingula* (*Lingulella*) *Davisii*. It is equally remarkable for its Crustacea (*Paradoxides*, *Oleni*, *Agnosti*, *Hymenocaris*, &c.). Loc. Dolgelly, Barmouth, Ffestiniog, St. David's, &c.

CAMBRIAN ROCKS

Dark-green, grey, black, and brown flags, also grits and conglomerates, occurring at Harlech, Anglesea, Llanberris, St. David's, the Longmynd, &c., with few fossils.

LAURENTIAN ROCKS

"Fundamental Gneiss" of Murchison. Western promontories of Ross and Sutherland, the Lewis, Lews, or Long Island, including Harris, and other parts of the Hebrides.

low bone-bed in the Old Red Sandstone or Devonian. But I have shown that the presence of the peculiar small Ichthyolites, *Plectrodus mirabilis* and *Onchus Murchisoni*, 'Sil. Sys.' (which have never been found in the Old Red Sandstone), afford no reason for separating this fish-bed from the Ludlow Rocks, seeing that it is filled with unequivocal Silurian marine shells, some of which occur even low down in the system ('Siluria,' ed. 1859, p. 157, note).

Fossil Fishes have also been found in the highest bed of the Upper Silurian of the Baltic island of Ösel (*Thyestes verrucosus*, Eichwald, and *Cephalaspis Schrenkii*, Pander; see the memoir by F. Schmidt, 'Imper. Mineral. Soc. St. Petersburg,' 1865-6). There also, as at Ludlow, the Ichthyolites are intermixed with marine Upper Silurian forms, such as *Platyschisma helices*, *Orthis*, *Ptilodictya*, *Chonetes*, *Pterinea*, *Orthoceras*, *Calymene*. Again, just as in Britain, none of the true Old Red Sandstone fishes, so common in Russia, occur with these peculiar Ichthyolites of the youngest Silurian strata.

BRITISH SILURIAN BRACHIOPODA.

FAMILY—LINGULIDÆ.

OF this family the genera *Lingula*, *Lingulella*, *Obolus*, and *Obolella* are represented in the British Silurian rocks.¹

Genus—LINGULA, *Bruguière*, 1789.

In pages 199—205 of my 'Monograph of the British Carboniferous Brachiopoda' I have given at some length the characters, both external and internal, of this genus; and thereto the student is referred in order to avoid repetition.

It is, however, no easy matter, if even possible, always satisfactorily to distinguish the numerous so-termed species that have been referred to this genus, their shapes in many cases differing but little one from the other, not only in the Silurian rocks, but also throughout the entire sequence of geological formations. Many of these species are more or less longitudinally oval, with valves slightly convex, sides either straight or moderately curved, front straight or rounded, beaks more or less sharply acuminate. In such cases, where the general form appears to differ so little, it is almost impossible in the present state of our knowledge to point out, and especially by words, those very minute differences, real or imaginary, which may have been adduced as reasons for applying to certain forms a separate specific designation. There are, however, in the number many well-marked and apparently distinct species, at all times easily recognisable. The recent species are few in number; but, besides a certain difference in their respective forms, most of them may be distinguished by their colour. Thus, Mr. L. Reeve describes *L. ovalis* as of a brilliant verdigris-blue-green colour; *L. tumida* is brownish- or reddish-olive; *L. murfina* of a peculiar coppery red tone of colour; *L. abina* and *L. semen* are whitish;

¹ As, on account of its great length and the number of plates required, this Monograph must be issued in several consecutive portions, the author earnestly requests those who may possess species not described under the several genera will kindly communicate with him upon the subject. Additional information as to any of the species will find a place in the "Supplement."

L. antillarum is faintly tinged with blue-green towards the umbones; *L. exusta* is reddish-yellow, deeply stained with brown towards the margin; *L. anatina* exhibits a peculiar coppery redness, heightened in parts to a shining swarthy tone of colour; and *L. hians* is pale green;¹ but none of the many fossil species hitherto collected throughout the entire sequence of sedimentary deposits, from the Lingula-flags upwards, have shown the smallest vestige of colour; unless, perhaps, *L. Symondsii* from the Wenlock Shale. We are, therefore, deprived of that help, so useful among the recent forms, to aid us in the discrimination of our fossil shells, which must, when alive, have presented the brilliant green, blue, and other tints so much admired in their recent congeners. Again, how many of the fossil forms resemble in contour such shells as the large recent *L. tumida*, *L. ovalis*, and *L. anatina*! It is, moreover, rare to meet with the internal surface, even in the larger number of fossil species; and it is not often that we find specimens showing the two valves united,—a circumstance easily explained by the fact, that, when alive, the valves were slightly gaping at each end, and closed only along the lateral margins; consequently, when dead, the valves became easily separated and scattered. Until a carefully elaborated general monograph of this genus shall have been prepared, much uncertainty and vagueness must exist with reference to a certain number of the species and their synonyms.

The angle formed by the junction of the slopes of the beaks has been made use of as a character by some palæontologists: but after having measured the angle in numerous species, and specimens of the same species, I found it so variable as to preclude the possibility of making use of it as a distinctive character of great stability or importance; and, indeed, the proportions of breadth and width, though, of course, to some extent available, are not usually to be relied on fully: the surface-characters are best.

In the published catalogues some twenty-five or twenty-six species (?) of British Silurian Lingulæ have been enumerated, but of these two or three are manuscript designations, appended provisionally by Mr. Salter to tablets in the Museum of the Geological Survey, while some others are either synonyms or species not yet sufficiently determined.

British Species apparently well determined.

1. <i>Lingula Lewisii</i> , Sow.	9. <i>Lingula attenuata</i> , Sow.
2. — <i>tenuigranulata</i> , M'Coy.	10. — <i>ovata</i> , M'Coy.
3. — <i>granulata</i> , Phillips.	11. — <i>Ramsayi</i> , Salter.
4. — <i>crumena</i> , Phillips.	12. — <i>lata</i> , Sow.
5. — <i>Rouaulti</i> , Salter.	13. — <i>striata</i> , Sow.
6. — <i>Hawkei</i> , Rouault.	14. — <i>cornea</i> , Sow.
7. — <i>Lesueuri</i> , Rouault.	15. — <i>Salteri</i> , Dav.
8. — <i>Symondsii</i> , Salter, MS.	

¹ See the beautiful figures of recent *Lingula* published in G. B. Sowerby's 'Thesaurus Conchyliorum' (for 1846), and in Mr. L. Reeve's 'Conchologia Iconica,' article "Lingula."

British Species (?) not yet sufficiently made out.

16. <i>Lingula</i> Bechei, <i>Salter, MS.</i>	21. <i>Lingula</i> minima, <i>Sow.</i>
17. — squamosa, <i>Holl.</i>	22. — pygmæa, <i>Salter.</i>
18. — parallela, <i>Phillips.</i>	23. — brevis, <i>Portlock.</i>
19. — longissima, <i>Pander.</i>	24. — obtusa, <i>Hall (M'Coy).</i>
20. — curta (<i>Conrad</i>), <i>M'Coy</i> = young <i>L. attenuata.</i>	25. — lepis (<i>Lingulella</i>), <i>Salter.</i>

There are also one or two other uncertain forms; hence it is very probable, as already stated, that several of these ten last-named species (?) may, when better known, prove to be either synonyms, varieties, or variations in form of some of the fifteen first named. I have, however, considered it desirable, in the present state of our knowledge, to give short descriptions as well as figures of the entire series, so that the student may form his own opinion upon the matter, and not have to depend upon my views alone.

LINGULA LEWISII, *Sow.* Pl. III, figs. 1—6.

LINGULA LEWISII, *Sow.* Silurian System, pl. vi, fig. 9, 1839; and Siluria, pl. xx, fig. 5, 1859.

— — *Dav.* Bull. Soc. Géol. France, vol. v, 2nd ser., p. 333, pl. iii, fig. 44, 1848.

— — *M'Coy.* British Palæozoic Fossils, p. 253, 1852.

Spec. Char. Subquadrate, oblong, longer than wide; sides almost parallel; front very slightly rounded; beaks obtusely angular, the slopes rarely straight; valves almost equally deep, the convexity very small; surface nearly smooth, or marked with numerous concentric raised lines or ridges of growth, and here and there by more deeply indented striæ.

Length 14, width 10, depth $2\frac{1}{2}$ lines.

Obs. This well-known species is easily distinguishable from *L. granulata* and *L. tenuigranulata* by its surface not being reticulated. Good interiors or internal casts are sometimes obtained, of which representations will be found in our plate.

Position and Locality. This species is stated to have been found in the Woolhope beds, Wenlock shale and limestone, Lower Ludlow and Aymestry limestone; but is most abundant in the last-named formation. It occurs in the Lower Ludlow rock of Mortimer's Cross, Aymestry, Herefordshire; also in the Aymestry rock at Sedgley, between Dudley and Wolverhampton; at Mary Knoll, and many other localities in the Ludlow promontory. Prof. M'Coy mentions its occurrence in the Lower Ludlow rock of Leintwardine, Shropshire, and in other places in the same county. Mr. Lightbody states that he finds *L. Lewisii* in the Upper Ludlow series, but rarely; and near the top of that series abundance of another form, rather smaller, which he would be disposed to regard

as *L. Lewisii*, if that species had not been so rare in the Upper Ludlow: a fine large specimen, which we figure, was, however, found by Mr. Lightbody in the Upper Ludlow of Whitecliff, at Ludlow. In Ireland, Prof. M'Coy mentions its occurrence in grey quartzites at Shanballymore, Oughterard, County Galway, and in shales at Ardaun, Cong; but his example, of which I give a figure, is not so broad as we find to be the case in the generality of specimens; and as these are "Llandovery" localities, its occurrence there is not likely.

Prof. Phillips quotes the following localities in his 'Memoir on the Malvern Hills,' &c.:—*Malvern District*, West of Rilbury, in the Aymestry limestone. *Abberley District*, Ankerdine Hill, Aymestry limestone; Hole Farm, Lower Ludlow. *Woolhope District*, South of Putley, Aymestry limestone; Shucknall Hill, Aymestry limestone; Ecknall Copse; Bodenham, Aymestry limestone. *Usk District*, Usk; Cilfigan (Wenlock beds); Tucking Mill (Wenlock beds). *Llandeilo District*, Cilmaen Llywd (Ludlow rocks). *Freshwater District*, Freshwater East (Ludlow rocks).

LINGULA GRANULATA, *Phillips*. Pl. II, figs. 15—18.

LINGULA GRANULATA, *Phillips*. Mem. Geol. Sur., vol. ii, part i, p. 370, pl. xxv, 1848.

— — *M'Coy*. British Pal. Foss., p. 252, 1852.

— — *Salter*. Siluria, p. 212, fig. 4, 1859.

Spec. Char. Somewhat pentahedral in outline, longer than wide; the sides nearly straight and parallel, rounded into the straight front; slopes forming the acuminate beak nearly straight and uniting at an angle of about 120° ; valves very slightly convex, flattened along the middle; surface marked by numerous regular equidistant rows of concentric prominent ridges, which are wider or larger towards the middle of the shell; these ridges are also crossed by another set of radiating longitudinal striæ, more closely disposed than are the concentric wrinkles, and producing by their intersection a granulose or reticulated appearance.

Length of a large specimen 12, width 8 lines.

Obs. Prof. Phillips gives us an excellent description and figure of the exterior of one of the valves of his species; unfortunately the interior is unknown. He observes that "the transverse striations are formed in sets, being extremely regular and at equal distances for many rows, and afterwards equally regular but at smaller distances apart" (but this applies especially to the specimen described; in other examples the transverse striation gradually diminishes from about the middle of shell to the posterior and anterior margins). "The surface appears granulated. The reticulation is less evident on the sides and on young individuals. In young specimens the outline is less characteristically marked, being in fact ovato-acuminate. (In other *Lingulæ*, as in this, the lateral expansions near the beak increase and become characteristic with age.) The shell is always very

black, and its small reticulated fragments have been found in several places about Llandeilo."

Prof. M'Coy gives us also a good description of this shell, and adds that the obtuse tuberculation is distinctly visible to the naked eye in good lights, and completely distinguishes this species from *L. tenuigranulata* of M'Coy; but, on the other hand, it appears to be identical with that of *L. cancellata*, Kutorga, from the Pulkowa limestone ('Ueber das Sil. und Dev. Schicht.-Syst., von Gatschina,' 'Verhandlungen der Russ. Kaiserl. Min. Gesellschaft zu St.-Petersburg,' for 1845, t. vii, p. 119, fig. 5), from which species, however, its great width and straight front seem to distinguish it perfectly.

Position and Locality. This species has been hitherto found only in the Llandeilo and Caradoc beds. Prof. Phillips obtained it in the *Llandeilo District*, at Llandeilo; North west of Gwenllwyn; also at Tre Gib; and in the *Haverfordwest District* at Mydrim and Lann Mill. Prof. M'Coy states it to be common in the Bala limestone of Llandeilo, Carmarthenshire; but this is an error, according to Mr. Salter, *L. ovata* having been taken for it. The largest specimen I have seen is in the possession of Mr. G. H. Morton, of Liverpool.

LINGULA TENUIGRANULATA, M'Coy. Pl. II, figs. 9—14.

LINGULA TENUIGRANULATA, M'Coy. Ann. Mag. Nat. Hist., 2nd series, vol. viii., p. 406, 1851; and British Pal. Foss., p. 254, pl. 1 L, fig. 8, 1852.

— — — Salter. Siluria, p. 212, fig. 5, 1859.

Spec. Char. Shell large, semi-elliptical, longer than wide; lateral margins nearly straight and parallel, but the shell is somewhat broader anteriorly than posteriorly; front margin nearly straight or slightly convex, the anterior angles abruptly rounded, posterior margin forming rather abrupt slopes uniting in the middle so as to form very obtusely pointed beaks, but the extremity of the beak of the ventral valve is somewhat more elongated and pointed than that of the ventral one; valves almost equally and moderately convex, flattened along the middle. Exterior surface finely imbricated, or closely covered with minute radiating, raised, granulate striæ, with interspaces between them, a little wider than the width of the interrupted ridge, the tubercles near the beaks and margins being almost detached, and forming a linear succession of small elevated granules or elongated drops. The shell and ridges are also crossed by minute, concentric, slightly undulating, elevated lines. Two specimens measured—

Length 22, width 14, depth 5 lines.

„ 19, „ 15, „ 4 „

Obs. This fine species has been very well described by Prof. M'Coy, who also mentions that it is distinguishable from *L. granulata*, Phillips, by the extremely minute granular

lineation of its surface, which is invisible to the naked eye, but under the lens presents a beautifully reticulated sculpture. As many as about twenty-six of these raised striæ may be counted in the breadth of one line towards the middle of the shell. It is not always, however, that we find specimens having their outer surface preserved, most examples being decorticated and of a black colour. I have seen a great many specimens of this shell sometimes showing both valves united; but in no case did the beak of the ventral valve so much exceed in length that of the dorsal one as is described and represented by Prof. M'Coy,—“the beak of the larger valve extended a quarter of an inch beyond the ventral margin of the other.”

In size and shape the shell under description so closely agrees with *Lingula Canadensis*, Billings ('Geology of Canada; Palæozoic Fossils,' vol. i, p. 114, fig. 95, June, 1862), that I am almost tempted to place this last as a synonym of *L. tenuigranulata*; but not having seen specimens of the Canadian shell, and as Mr. Billings states that it is less wide and more coarsely reticulated, it will for the present be better to leave the question undecided. In size, *L. tenuigranulata* much exceeds *L. Lewisii*, *L. granulata*, and *L. quadrata* of Eichwald, &c.

Position and Locality. This species appears to be at present known only from the Caradoc (?) beds. It is common in the sandy and calcareous schists of Alt-yr-Anker, Meifod, and in sandy Bala schists of Das Eithin ridge, Hirnant, Montgomeryshire; from whence the specimens described by Prof. M'Coy were obtained. I have seen numerous examples from the Bala shales north of Llanfyllin, Fron-goch, Meifod, near Welshpool; Pwll-y-wrach, near Llanwddyn, and Pistyll Cwmllech, Llanfyllin, &c. Prof. Harkness has also found small specimens of this species in the Lower Bala shales ("Dufton fossiliferous shales" of Harkness) at Pusgill, near Dufton, in Westmoreland. Mr. Edgell has it also from the Caradoc of Cheney Longville, Salop.

LINGULA OVATA, M'Coy. Pl. II, figs. 19—23.

LINGULA OVATA, M'Coy. Synopsis Sil. Foss., Ireland, p. 24, t. iii, fig. 1, 1846.

Spec. Char. Elongated, greatest width about the middle; sides sub-parallel, nearly straight or very slightly convex, and merging gradually, so as to form an acuminate pointed beak; front very little rounded, sometimes almost straight; valves depressed, their convexity being very small; the surface is almost smooth, or marked with fine concentric lines of growth. Professor M'Coy's figured specimen measured—

Length 15, width 8 lines.

Obs. This common species is distinguished from *L. Lewisii* by its greater length in proportion to its width; and (as remarked by Prof. M'Coy) it bears much resemblance in shape to some specimens of the well-known Carboniferous *L. squamiformis*. Its

remarkably subparallel sides and rounded point easily distinguish it from *L. attenuata*; and the same characters will separate it from *L. parallela*, Phillips. I am very much inclined to believe, however, that the specimen figured as *Lingula ovata* by M'Coy ('British Pal. Foss.,' pl. 1 L, fig. 6), from the Lingula-shales south of Penmorfa, Tremadoc, North Wales, is nothing more than an elongated specimen of *Lingulella Davisii*, having myself seen many specimens of the last-named shell assuming that shape. Mr. Salter assures me also that this is the case; and that *Lingula ovata* is strictly a Caradoc or Bala shell.

Position and Locality. *Lingula ovata* was first described and figured by Prof. M'Coy from a specimen found in the Caradoc (?) shale of Ballygarvan Bridge, County Wexford; and is likewise stated to occur at Cahiranearla, or the Chair of Kildare; as well as in shale at Newtown Head, County Waterford. It was found by Mr. D. C. Davies in a light-coloured Caradoc sandstone near Bala, also east of Bala Lake, Merionethshire. In Montgomeryshire it occurs at Llanwddyn and Meifod. Mr. Lightbody has obtained this shell from the Caradoc of Marshbrook. In Denbighshire it is met with south of Llangollen; and it was also found by Prof. Harkness in the Lower Caradoc or Bala shales ("Dufton fossiliferous shales" of Harkness) at Pusgill, Dufton, Westmoreland.

LINGULA PARALLELA, *Phillips*. Pl. II, figs. 24—27.

LINGULA PARALLELA, *Phillips*. Memoirs of the Geological Survey of Great Britain, vol. ii, part 1, p. 370, pl. xxxvi, fig. 1, 1848.

Spec. Char. Elongated, ovate, broadest anteriorly; sides sub-parallel, merging gradually into the slopes which form the acuminate pointed beaks; front slightly curved; valves very gently convex and flattened along the middle; surface longitudinally and faintly striated, with still smaller longitudinal lines occupying the wide interspaces between the larger striæ: concentrated lines of growth are also observable.

Length 11, width 6 lines.

Obs. This shell seems to be nearly related to the preceding one, but apparently distinguishable by the flatness of its valves, its very square front, and flattened middle area, as well as by the longitudinal striation of its surface.

Position and Locality. *L. parallela* has been hitherto found only in the Upper Llandovery or May Hill sandstone. The specimens described by Prof. Phillips were obtained at Gunwick Mill, Malvern; and the typical examples are to be seen in the Museum of the Geological Survey. This species does not appear to be rare, being found at the Obelisk, Eastnor Park, as well as at the Wych, all three sections being in the Malvern District.

LINGULA ROUAULTI, *Salter*. Pl. I, figs. 14—20.

Quarterly Journal Geol. Soc., vol. xx, pl. xvii, figs. 4, 5, 1863.

Spec. Char. Shell thick, triangular, longer than wide; front either straight or slightly convex; sides gently arched and converging, so as to produce in the larger valve a tapering pointed beak; dorsal valve a little shorter than the opposite one, uniformly and highly convex; the ventral not so deep as the dorsal valve, and flattened along the middle; beak of the ventral valve produced about two lines beyond that of the dorsal valve. External surface marked by numerous more or less strongly indented concentric lines of growth. Two specimens measured—

Length 23, width 17 lines.

„ 19, „ 16 „ depth 9 lines.

Obs. This curious species appears to be not uncommon in the Lower Silurian “Armorican Grit,” or quartzite boulders at Budleigh Salterton, in Devonshire, and is also now and then found with its two valves united. All the specimens I have seen were longer than wide, while *L. Brimonti* is stated by M. Rouault to have been wider than long; and it would appear that both it and the species under description were thick, robust, and remarkably convex shells, more so, indeed, than is usual with the generality of species of the genus. We have also the interior (although not perfectly preserved) of the dorsal valve, which shows that its muscular scars agreed in shape, as well as in position, with those observable in other species of *Lingula*; while strong radiating striæ are also visible on the internal cast. This species was well described and figured by Mr. Salter. It approaches somewhat in shape to *L. crumena*, Phillips; but of the last-named shell we have not hitherto obtained bivalved examples, and, consequently, cannot say whether it was as convex as *L. Rouaulti*. Mr. Salter considers the two to be perfectly distinct.

LINGULA CRUMENA, *Phillips*. Pl. II, figs. 1—6.

LINGULA CRUMENA, *Phillips*. Memoirs of the Geological Survey of Great Britain, vol. ii, part i, p. 369, pl. xxiv, 1848.

— — *Murchison*. Siluria, p. 74, fig. 5, 1859.

Spec. Char. More or less triangular or cuneiform, widest anteriorly; sides either regularly and very slightly convex from close to the front to the extremity of the pointed beak, or the convex sides form an inward curve at about their middle; beak acuminate and acutely pointed; front gently convex, sometimes nearly straight; ventral valves moderately convex, but in some instances flattened along the middle, and marked by more or less strongly indented lines of growth.

Length of a large example 20, breadth 14 lines.

Obs. This shell is very variable in its outline, as may be seen from the figures in our plate, several of which were taken from the original specimens illustrated by Phillips. It is also one of our largest species of *Lingula*. Although not exceedingly rare in the Upper Llandovery of Howler's Heath, in the Malvern district, no bivalve example has, to my knowledge, been hitherto collected. When young, some specimens resemble *L. attenuata*, but adult examples can always be readily distinguished from the latter. *L. crumena* occurs in the Pentamerus-conglomerate at Kinley, Shropshire. (Museum of the Geological Survey.)

? ¹LINGULA SQUAMOSA, *Holl.* Pl. II, fig. 7.

LINGULA SQUAMOSA, *Holl.* Quarterly Journal Geol. Soc., vol. xxi, p. 102, 1864.

Although briefly described by Dr. Holl as "triangular, broad anteriorly, compressed; beak acute; anterior margin truncate; shell thick, strongly grooved from side to side by imbricating lines of growth; length quarter inch," no specimen was entire enough to enable the author to figure his shell; and, consequently, on such incomplete and unsatisfactory material not much can be said either as to its characters or specific value. In my plate I have ventured to give a slightly restored representation of the shell, taken from one or two of Dr. Holl's fragmentary specimens, and which indeed strongly reminds us of certain young examples of *Lingula cuneata*, Conrad (Hall, 'Pal. of New York,' vol. ii, p. 8, pl. iv, fig. 2). *L. squamosa* is stated by Dr. Holl to occur in the light-brown felspathic Hollybush sandstone in the Malvern Hills; and he agrees with Mr. Salter in considering this sandstone to be equivalent to the middle division of the *Lingula*-beds of North Wales.

? LINGULA HAWKEI, *Rouault.* Pl. I, figs. 21—26.

LINGULA HAWKEI, *Marie Rouault.* Bull. Soc. Géol. France, 2nd series, vol. vii, p. 728, 1850.

— — *Salter.* Quarterly Journal Geol. Soc., vol. xx, p. 293, pl. xvii, figs. 2, 3, 1863.

— *BRIMONTI, Salter.* Ibid., fig. 6.

Spec. Char. Variable; somewhat sub-quadrate, with rounded angles, broadest anteriorly; usually a little longer than wide; sides more or less convex; front either

¹ A point of interrogation placed before the specific name, as above, will indicate that some uncertainty as to the value of the species is entertained by the author of this Monograph, or that its characters have not been sufficiently determined.

nearly straight and slightly indented, or presenting a very gentle convex curve; beak short and very obtusely acuminate; valves moderately convex. Surface marked with numerous more or less deeply indented concentric lines of growth. Two specimens measured—

Length 13, width 12, depth 5 lines.

„ 13 „ 13½ „ „ „

Obs. Unfortunately, M. Marie Rouault figures none of the many Brachiopoda he has described in the seventh and twentieth volumes of the 'Bulletin;' and, although his descriptions are generally carefully worded, it is well known that a figure is indispensable with reference to new species, and that no description will compensate for the omission.¹ Therefore, without being able to compare our Budleigh Salterton specimens with those found in Brittany, it is difficult to be absolutely certain with reference to the present identification. The French palæontologist, moreover, informs us that his shell is of an almost circular form, a little longer than wide; and I do not know whether our British specimens are sufficiently so to answer to the French description, which would agree more closely with the shell we have described further on as *L. Salteri*; but as the shell has been so described and figured by Mr. Salter, I will for the present abide by his decision.²

L. Hawkei, as well as all its congeners, appears to have been liable to malformation, or to present a greater or lesser depression in one of its valves, together with an indentation or emargination of its front, under which condition is the specimen which Mr. Salter thought might be identified with Rouault's *Lingula Brimonti*; several examples, however, subsequently found by Mr. Vicary, clearly showed that this was not the normal condition of a species, and they may therefore be united with the above.

As to geological age, it is the same as that of *L. Lesueuri* and *L. Rouaulti*, namely, the horizon of the *Armorican sandstone* of Rouault, which he places in the Lower Silurian.

LINGULA LESUEURI, Rouault. Pl. I, figs. 1—11.

LINGULA LESUEURI, *Marie Rouault*. Bulletin Soc. Géol. France, vol. vii; 2nd series, p. 727, 1850.

— — — *Salter*. Quarterly Journal Geol. Soc., vol. xx, p. 292, pl. xvii, fig. 1, 1863.

¹ So necessary is this found to be, that the Geological Society of France within the last few years determined not to publish in their 'Bulletin' the description of any new species unaccompanied by a figure.

² M. Rouault describes his *Lingula Hawkei* in the following words: "Longueur, 42 millimètres [20 lines]; largeur, 38 millimètres [18 lines]; épaisseur, 20 millimètres [16 lines]. Coquille de forme presque arrondie: un peu plus longue que large; plus développée en avant; renflée vers le haut; s'aminçissant vers le bord: sans côtes à sa surface: lignes d'accroissement très-marquées. Se distingue de *L. dubia*, D'Orb., par sa forme plus allongée et son plus grand développement; et de *L. quadrata*, Eich., par sa largeur, qui est plus grande en avant, et beaucoup moindre en venant gagner la charnière. Localité: Guichen [Brittany]."

Spec. Char. Shell depressed, slightly convex; very much elongated; sides usually more or less sub-parallel for about half their length from the front, and from thence gradually sloping by gentle curves until they unite at the beaks; front very gently curved, almost truncated. Surface marked with numerous concentric lines of growth, which at intervals are more strongly indented, and by very fine radiating striæ, which intersect the concentric ones. Interior unknown; but two depressions or pits in the cast are seen close to the extremity of the beak. Proportions variable; two specimens measured—

Length 13, width 8 lines.

„ 14 „ 7 „

Obs. Some thirty or more examples of this curious shell have been found by Mr. Vicary in the pebbles of grey and reddish sandstone or quartzite at Budleigh Salterton, in Devonshire, and were at once identified by Mr. Salter as agreeing with the descriptions published by M. Rouault in 1850. Mr. Vicary found specimens of all stages of growth, from three lines in length to nearly two inches. It would not be quite correct to say that the sides are always strictly parallel for more than half the length of the shell; for in many examples they begin to gradually taper almost from the front, as may be seen in the specimens figured. In France *Lingula Lesueuri* occurs at Guichen, in Brittany, in a white or bluish sandstone or quartzite, belonging to the Lower Silurian series, and forming part of M. Rouault's "étage du gris Armorican."¹ In Great Britain we do not find this sandstone *in situ*; but these and other fossils of the "Armorican stage" occur in well-rolled pebbles or boulders, which vary from a small size to that of a man's head, and which are generally of a flattened oval form.² These boulders, together with others containing fossils apparently of another period, appear to have been drifted from some distance, and to have been accumulated in a bed, whose greatest thickness is stated by Mr. Vicary to be a little over a hundred feet. In his paper "On the Drifts in parts of Warwickshire," published in the British Association Reports for 1865, and also in the 'Geological Magazine,' vol. ii, p. 566, 1865, the Rev. P. B. Brodie mentions having found *L. Lesueuri*, together with *Orthis redux*, in quartzose pebbles and sandstone, similar to those described by Mr. Vicary from Budleigh Salterton.

It may still remain a question whether the shell which in the Museum of the Geological Survey bears the manuscript designation of *Lingula Bechei*, from the Upper Llandovery of Marloes Bay, may not be a variety of *L. Lesueuri*, for some of the specimens quite agree in shape with the Budleigh Salterton examples, though the surface is far rougher. M. Rouault observes that his species approaches most nearly to *L. Munsterii*, D'Orb., but that it may be distinguished from it by its more regular form, and the complete absence of three longitudinal furrows which characterise the Bolivian shell.

¹ See Messrs. Vicary and Salter's paper on the "Pebble-bed and Fossils of Budleigh Salterton," 'Quarterly Journal of the Geol. Soc.,' vol. xx, p. 283, 1863.

² Mr. Salter has lately published ('Geol. Mag.' April, 1866,) his view that these sandstones and shales of Brittany are of the age of the Arenig or Skiddaw slates (the "Lower Llandeilo" of Murchison).

? *LINGULA BECHEI*, *Salter*, MS. Pl. I, figs. 12—13.

Spec. Char. Shell much elongated, depressed; sides sub-parallel for some distance, or gradually tapering from near the front to the beak; front slightly rounded or almost straight; surface marked with numerous fine, undulating, small, concentric lines of growth, which at intervals are more deeply indented, and crossed by very fine radiating lines. Two specimens measured—

Length 17, width 9 lines.

„ 12 „ 6 „

Obs. I have already stated that, if this shell is not *L. Lesueurii*, or a variety of it, it is a very closely allied form; but I have provisionally retained Mr. Salter's varietal or specific designation of *Bechei*, since he considers the two to be quite distinct.

Position and Locality. Upper Llandovery, Marloes Bay.

LINGULA ATTENUATA, *Sow.* Pl. III, figs. 18—27.

LINGULA ATTENUATA, *Sow.* Silurian System, pl. xxii, fig. 13, 1839; and Siluria, pl. v, fig. 16, 1859.

[— — *Portlock.* Report on the Geology of Londonderry, &c., p. 443, pl. xxx, fig. 4, 1843 ?]

[— — *M'Coy.* Synopsis Sil. Foss. Ireland, p. 24, 1846 ?]

[— — *J. Hall.* Palæont. New York, vol. i, p. 94, pl. xxx, fig. 1, 1847 ?]

— — *M'Coy.* British Pal. Foss., p. 251, 1852.

— *CURTA* *M'Coy* (not of Conrad), *ibid.*, p. 251, 1852.

Spec. Char. Ovate-acute, longer than wide, sharply acuminate posteriorly or towards the beaks; anteriorly the sides and front are very much rounded; valves slightly convex; surface marked with numerous concentric lines of growth, which at irregular intervals are more deeply indented. A large example measured—

Length 9, width $6\frac{1}{2}$ lines.

Obs. This shell varies in the degree of acumination of its posterior portion or beak, the sides being more sub-parallel in some examples than in others. Prof. M'Coy states that it is, perhaps, more allied to *L. ovata*, M'Coy; but it really does not much resemble it, being considerably shorter and wider, with longer posterior lateral margins, besides being very much smaller; and these differences become greater as specimens of the two species approach each other in size.

Position and Locality. It occurs in the Llandeilo flags only, according to Mr. Salter. Very characteristic examples are found in the Llandeilo flags of Llandeilo and Shelve; also at Coed Sion, Llangadoc; Middleton, east of Chirbury; Rorington, Salop; Carneddau,

Builth district; &c. Mr. Lightbody has found the shell in the Upper Llandeilo beds west of Meadowtown. [Prof. Phillips states that *L. attenuata* occurs under the Worcester Beacon; at Storridge; Cowley Park Obelisk, in the Malvern district; and at Ankerdine Hill, Abberley district; all these localities being in the "Upper Caradoc" (as it was then called) or Upper Llandovery rocks. Prof. M'Coy mentions it from thin sandy (Bala) beds east of Nant-y-groes, south of Bala, North Wales. In Scotland it possibly occurs at Balclatchie, Girvan, Ayrshire; but these are Caradoc beds, according to our best authorities. In Ireland it has been identified from the Llandovery slates of Kilbride, Cong, County Galway; and General Portlock mentions Tyrone, Desertcreat.]¹

In N. America it is stated by Prof. Hall to occur in great numbers about midway from the base to the top of the Trenton limestone, also at about fifty or sixty feet above the Birdseye limestone.

LINGULA STRIATA, *Sow.* Pl. III, figs. 45—48.

LINGULA STRIATA, *Sow.* Sil. Syst., pl. viii, fig. 12, 1839; and Siluria, pl. xx, fig. 7, 1859.

Spec. Char. Squarish-ovate, longer than wide; sides slightly curved and sub-parallel; front gently convex, or nearly straight; posterior lateral margins sloping gradually, so as to form acuminate pointed beaks; valves very moderately convex and flattened along the middle surface, marked by numerous fine, concentric, raised, undulating ridges or striæ, with wider interspaces between them. Length 9, width 6 lines.

Obs. The concentric undulating striæ which ornament the surface of this species are exceedingly small, seventeen existing in the width of a line near the front, in Murchison's original specimen, so that they can hardly be perceived except by the aid of a lens; the interspaces between these ridges are irregular in their respective widths.

Position and Locality. *L. striata* has been found in the Lower Ludlow rock near Aymestry, also at Ledbury. It occurs likewise in the Wenlock shale, near Dudley. Mr. Lightbody states that near Ludlow the shell is peculiar to the upper beds of the Aymestry limestone; and that he has obtained it at Whitecliff, near Ludlow.

LINGULA SYMONDSII, *Salter*, ms. Pl. III, figs. 7—17.

Spec. Char. Longitudinally oval or ovate, broadest about the middle, slightly tapering at the beaks, rounded in front; valves moderately and evenly convex, one valve a little more so than the other; surface smooth, marked only with fine concentric lines of growth. A large example measured—

Length 12, width 7 lines; but the shell is more often smaller.

¹ Mr. Salter tells me that these Irish determinations are erroneous; fragments of other species occurring instead.

Obs. This *Lingula*, although distinct, bears resemblance to some variations in shape of *L. ovata*, M'Coy, a broader species.

Position and Locality. It occurs at Penlan Llandovery, and Mandinam, in the Upper Llandovery rocks; in Woolhope limestone at Sandbanks, Presteign; and at Ballard's Quarry, the Wych, Malvern; but it is most abundant in the Wenlock shale at Buildwas, Wenlock Edge; also near Dudley; Rushall Canal, near Walsall; Alfric Pound, Malvern; also in the Lower Ludlow of Ledbury; at Barr, Staffordshire, in Woolhope limestone. Specimens from nearly all these localities will be found figured in our plate.

LINGULA CORNEA, *Sow.* Pl. II, figs. 28—35.

LINGULA CORNEA, *Sow.* Silurian System, p. 603, pl. iii, fig. 3, 1839; Siluria, pl. xxxiv, fig. 2 and woodcut; foss. 22, fig. 3, p. 156, 1859.

— — M'Coy. British Pal. Fossils, p. 251, 1852.

Spec. Char. Oblong, sub-pentagonal; sides straight, nearly parallel, and posteriorly converging by a gentle curve so as to form obtusely angular beaks; front margin nearly straight or gently rounded; valves moderately convex, most so near the beaks, flattened anteriorly; shell thin, closely marked with delicate, slightly undulated lines or wrinkles of growth. A well-shaped specimen measured—Length 7, width 5 lines.

Obs. As some difference of opinion has been expressed as to what forms should be referred to this important species, as well as to its stratigraphical position, we will enter upon a few details in connection with the subject. *L. cornea* was first described by Mr. J. de C. Sowerby, at p. 603 of the 'Silurian System (1839),' as "compressed, oblong, rectangular, nearly half as long again as wide; texture approaching horny. Length 7, width 5 lines. *Loc.* Tin Mill, Downton, Ludlow." In the "Tabular Lists of Organic Remains," &c., published in the same work, *L. cornea* is placed in a column entitled "Middle and Lowest Divisions of Old Red Sandstone." In the adjoining column, devoted to the "Upper Ludlow Rock," is placed Sowerby's *Lingula minima*, which is described at p. 612 (pl. v, fig. 23), as follows:—"Oblong, elongated, with parallel sides, flat, smooth, and thin. Length 4 lines, width 2½ lines. The species of *Lingula* so nearly resemble each other, that it is difficult to distinguish them by words. The specimen may be the young of some other species. *Locality:* Delbury; Downton Castle." In 'Siluria' no mention is made by Mr. Salter of *L. minima*; while the original representation of *L. cornea* is given by him (namely, the one drawn in pl. iii, fig. 3, of the 'Silurian System.') as from "Upper Ludlow rock, Tin Mill, Downton." He admits, in a letter, that this should have been "Passage-beds."¹

The original type of *L. cornea* which occurs in the Passage-beds is variable in shape,

¹ Mr. Salter has subsequently separated these off as the lowest member of the Old Red Sandstone, and named them "Ledbury shales." See 'Quart. Jour. Geol. Soc.,' vol. xix, p. 494, 1863.

and occurs very often together with spines of *Onchus* and other Fish-remains. It is a much larger and more oblong and rectangularly shaped shell than the one met with in such profusion in the "Downton sandstone," underlying the "Passage-beds" above mentioned; and it has been a question with Mr. Lightbody whether the "Downton sandstone" shell should be considered specifically the same as *L. cornea* proper, since it appears to differ from it in shape, size, and locality.

Now, it is probable that Sowerby was himself impressed with the same uncertainty; and it was to the small elongated form from the "Upper Ludlow rock" or "Downton sandstone" that he originally applied the designation of *L. minima*; for under "Upper Ludlow rock" he makes no reference to *L. cornea*; and the dimensions given to *L. minima* coincide exactly with the average proportions of the specimens of *Lingula* which occur in the "Downton sandstone." The "Tin Mill beds," assigned by Sir Roderick to his typical *L. cornea*, are identical with the Passage-beds; and are higher up in the scale than the "Downton sandstone" where *L. minima* is located. The narrow form, or the one last named (states Mr. Lightbody) does not seem to appear till we get to the "Trochus-bed," a sandy bed forming the base of the "Downton sandstone," and, near Ludlow, lying about a yard above the Bone-bed, and containing a new *Modiolopsis*, *Platyschisma* (*Trochus*) *helicites* (though the last-named shell is also found in the mudstone intercalated with the Bone-bed), and a vast abundance of *Beyrichia Klædeni*. Thanks to Mr. R. Slimon, I have likewise been able to examine a number of *Lingulæ* termed *L. cornea* by Sir R. Murchison and Mr. Salter in their paper on the "Uppermost Silurian Rocks near Lesmahago, in Scotland" ('Quarterly Journal Geol. Soc.,' 1856). These *Lingulæ*, as in the "Downton sandstone," partake of the same character, but are smaller and more elongated than the typical *L. cornea* from the Passage-beds above. I would, therefore, (notwithstanding the statement made by Prof. M'Coy at p. 251 of his 'British Pal. Fossils,' namely, that *Lingula minima* does not show the slightest difference from *L. cornea* that he can perceive,) feel disposed to retain the term *cornea* for the form first described in the 'Silurian System,' and that of *minima* for the smaller and more elongated shell found in the "Downton sandstone" and Trochus-bed at Ludlow and Lesmahago.

Position and Locality. *L. cornea* occurs, therefore, in the "Passage-beds," which Sir Roderick Murchison considers to belong to the uppermost portion of his Silurian system (see 'Siluria,' chap. vii, p. 154, 1859). The typical form is abundant at Tin Mill, Downton; in the railway-cutting at the north end of Ludlow; at Brockhill and Steventon turnpike, near Ludlow.¹ [At p. 24 of his 'Synopsis Silurian Fossils, Ireland,' Prof.

¹ Mr. Lightbody, who has devoted much care to the study of the Ludlow locality, seems disposed to concur with Mr. Salter in considering these "Passage-beds" as part of the Lower Old Red Sandstone, because, according to the Rev. W. S. Symonds' section at Ledbury ('Quart. Journ. Geol. Soc.,' vol. xvii, p. 155), where the beds are continuous, they are 300 feet above the top of the "Downton sandstone." Though at Ludlow the junctions are all obscured, yet there is no doubt of these beds being above the horizon of the

M'Coy describes or mentions a *Lingula* under the above name from Doonquin, Dingle, County Kerry, and a figure of it will be found in our plate. It is certainly a distinct species.—J. W. S.]

? *LINGULA MINIMA*, *J. de C. Sow.* Pl. II, figs. 36—44.

LINGULA MINIMA, *Sow.* Silurian System, p. 612, pl. v, fig. 23, 1839.

— — — *unguiculus*, *Salter MS.*

Spec. Char. Shell small, oblong, elongated; sides curved, gradually merging into the slopes forming the acuminate pointed beaks; front rounded; valves slightly convex and marked with fine concentric striæ. Two specimens measured—

Length 4, width $2\frac{1}{2}$ lines (Sowerby's type).

„ 5 „ $2\frac{1}{2}$ „ (a Lesmahago specimen).

Obs. The reason for retaining this form as a separate species, or a named variety of *L. cornea*, has already been stated. Mr. Salter has given the MS. name of *L. unguiculus* to some small *Lingulæ* (in the Museum of the Geological Survey, figs. 42—44 of our Pl. II) which occur, with a spiral shell, in beds at the top of the Ludlow rocks at Birkenhead Burn, near Lesmahago; but these so closely resemble some of the Downton sandstone specimens of *L. minima*, that we prefer, at least for the present, placing them with the latter. Prof. Phillips, at p. 276 of vol. ii, part 1, of the 'Memoirs of the Geological Survey,' states that he found *Lingula minima*, Sow., in the Downton sandstone of Brock Hill, in the Malvern district.

Downton sandstone. Sir R. Murchison, Prof. Ramsay, and Mr. Salter examined the sections in his company; and all agreed in considering them to be higher in position.

Mr. Lightbody kindly sends me the following note with reference to his locality:—"In the 'Downton sandstone,' which underlies the 'Passage-beds,' I have never found any Mollusca except *L. minima* and a species of *Modiolopsis*. The 'Trochus-bed' is at the bottom of the Downton sandstone; and about three or four feet lower is the 'Bone-bed,' which is nearly at the top of the mudstone. *Spirifer elevatus* occurs in a layer a little under the 'Bone-bed;' and, lower still, *Pterinea retroflexa*. These upper beds are yellowish, and underlie the first quarry of Whitcliff next Ludford, and are thin and very fossiliferous—*Chonetes lata*, *Rhynchonella navicula*, *Rh. nucula*, *Orthis lunata*, *O. elegantula*, *Goniophora cymbæformis*, *Serpulites longissimus*; and most of these fossils occur also in the Lower Ludlow below; but in true Upper Ludlow I have never seen *Atrypa reticularis*, nor any *Strophomenæ*. These last come in with the Aymestry upper beds abundantly; but these beds have been sometimes, and especially in Whitcliff, confounded with the Upper Ludlow, and consequently the *Rh. navicula* band has been put too high up. This bed really belongs to the Upper Aymestry limestone; and even above it can still be seen traces of the honeycomb-structure which has been referred to by Sir R. Murchison as characteristic of the Aymestry limestone. These Upper Aymestry beds are interlaced with calcareous bands, which the Upper Ludlow is not; and below them the limestone gets stronger, and composes the mass of the rock, though still too argillaceous to burn into lime. Below this again come the beds of *Pentamerus Knightii*, like an oyster-bed crammed full of shells crushed together; this they burn as lime. Then come the Lower Ludlow beds; and, as seen at Mocktree, one cannot tell where the Aymestry limestone ends and the Ludlow begins in that fine section along the turnpike-road."

Position and Locality. The position has already been explained. It occurs on the Old Leominster Road, near Ludlow; at Downton Castle; near Lesmahago, in Lanarkshire, &c.

(?) *LINGULA RAMSAYI*, *Salter*. Pl. III, figs. 49—52.

LINGULA RAMSAYI, *Salter*. *Siluria*, p. 55, Woodcut foss. 10, fig. 20, 1859.

Spec. Char. Ovate, longer than wide; sides slightly convex, merging posteriorly by a gentle curve into the acuminate beak, and anteriorly into the more or less rounded front; valves very slightly convex. External surface finely reticulated, the radiating raised lines being crossed by still finer concentric ridges, and thus leaving minute quadrangular spaces between them. Dimensions variable; a large specimen measured about an inch in length by something less in width.

Obs. Mr. Salter had no opportunity to describe his species; but he gave it a name, and placed a reduced figure of it among the characteristic fossils of the Llandeilo flags, in ‘*Siluria*,’ 2nd edit. Although I have seen a good number of specimens of this species, none exactly retain their true shape, and I am not quite sure about its real form, the shells being usually flattened and distorted, from the effects of pressure, cleavage, and fossilization. The external surface is rarely preserved, so that a further search for better examples would be very desirable. This species is very abundant in the only locality known.

Position and Locality. *L. Ramsayi* occurs in black Llandeilo flags at Aberiddy Bay, Pembrokeshire; specimens may be seen in the Museum of the Geological Survey, London.

LINGULA LATA, *Sow.* Pl. III, figs. 40—44.

LINGULA LATA, *Sow.* Murchison’s *Silurian System*, p. 618, pl. viii, fig. 11, 1839; and *Siluria*, 2nd edit., pl. xx, fig. 6, 1859.

— — *M’Coy.* *British Pal. Foss.*, p. 253, 1852.

Spec. Char. Shell small, ovate, longer than wide; sides slightly convex, and gradually converging into the rounded slopes which form the obtusely angular beaks; front gently rounded; valves very slightly convex. Surface marked with fine concentric lines of growth. Length 3, width 2 lines.

Obs. This important little shell is described by Sowerby as “obovate, flat, smooth; front edge truncated; width about 2 lines, length 3 lines. *Loc.*, Ludlow escarpment,

Elton, Evenhay." But it is only flat from pressure, for well-preserved specimens are gently convex, and the front edge is not truncated, but rather rounded, as Sowerby's original figure clearly shows.

Position and Locality. In the typical localities near the town of Ludlow, it is found in Lower Ludlow rocks, occurring at Vinnal Hill, at Elton, and Church Hill, near Ludlow; also in a bed close to the "bone-bed" at Ludford Lane, Ludlow. Also in Lower Ludlow at Ledbury and Aymestry, as well as in the Aymestry limestone of Mocktree, near Leintwardine, Shropshire; also at Kendal, Westmoreland, &c. In Scotland, in the Ludlow beds of the Pentland Hills, where it was first discovered by Mr. D. J. Brown, of Edinburgh.

I am very much puzzled to distinguish specimens found in the Lower Silurian rocks, and known by the name of *L. brevis*, Portlock, from *L. lata*, Sow., for they differ but little in size and shape, as may be seen from the series of figures in Pl. III, where both species are illustrated. I can scarcely believe that *L. lata* lived also in the Llandovery and Caradoc periods, although, to my mind, such would not be an impossibility; however, since many palæontologists might differ from me upon this subject, I will provisionally retain *L. brevis* as a separate species: and I am quite certain that the shell described and figured as *L. lata* by Portlock from Tyrone, Desertcreat, in Ireland, does not belong to the species described by Sowerby under that designation.

(?) *LINGULA BREVIS*, *Portlock*. Pl. III, figs. 34—39.

LINGULA BREVIS, *Portlock*. Report on the Geology of the County of Londonderry and of part of Tyrone and Fermanagh, p. 443, pl. xxxii, fig. 2, 1843.

Spec. Char. Shell small, ovate or oval; sides gently curved; beak acuminate; front rounded; valves very slightly convex, and marked by fine lines of growth.

Length 4, width 3 lines.

Obs. This so-termed species has given me no little trouble, for it was not, at first, possible to find Portlock's figured type; and several examples labelled *L. brevis* in the Museum of the Geological Survey of Ireland differed slightly from Portlock's figure, but still, I think, not sufficiently so to admit of another designation.

Portlock describes his *L. brevis* as follows:—"Acuminated retrally, but quickly attaining the full breadth; sides sub-parallel; front flat, rounded; length to breadth 5 to 4; surface flattened, smooth, and very faintly marked by lines of growth. This has a short wide aspect; but it may be the young of another species, the breadth not increasing [in this genus] in the same proportion as the length. Three specimens, all small, .19" long.

Loc. Tyrone, Desertcreat: Sheet 37, No. 2."

After considerable search Mr. Etheridge found, in the Museum of Practical Geology,¹ Jermyn Street, London, the specimen fig. 36 of our Pl. III, with one of Portlock's original labels, "*Ling. brevis*," attached to it. It may be one of the three specimens mentioned in that author's description: it is a little more regularly oval than is Portlock's figure; his illustration may, perhaps, not be entirely correct. In the Museum of the Geological Survey of Ireland a number of small oval Lingulæ from the Caradoc of Desertcreat, Tyrone (Portlock's locality), agree with the specimen found in the museum at London. Other examples from Tramore, Newtown Head, county Waterford, as well as from Rathdrum, Wicklow, in the same collection, are similar to those above described, and are likewise all labelled *L. brevis*. Therefore I think we cannot do better than adopt Portlock's name for the shells defined above; and a series of carefully drawn figures from the different localities named will be found in our plate. *L. brevis* approaches sometimes in size and appearance to certain examples of *Lingula Iole* of Billings ('Geology of Canada,' Palæozoic fossils, vol. i, p. 215, fig. 199); but the Canadian shell is more rapidly acuminate towards the beak than is Portlock's species.

Position and Locality. The Irish specimens are all referable to the Caradoc rocks. [Prof. Harkness quotes the same shell from the "Skiddaw Slates" of Outerside, near Keswick, in Cumberland. These, which are the lowest sedimentary rocks of that county, have been determined by Salter to include equivalents both of the Lower and Upper Llandeilo rocks of Murchison.]

(?) LINGULA LONGISSIMA, *Pander*. Pl. III, fig. 28—30.

- | | | |
|---------------------|-----------------|--|
| LINGULA LONGISSIMA, | <i>Pander</i> . | Beiträge der Geognosie des Russischen Reiches, pl. iii,
fig. 21, 1830. |
| — | — | <i>De Verneuil</i> . Geology of Russia and the Ural Mountains, vol. ii,
p. 293, pl. i, fig. 11, 1845. |
| — | — | <i>Kutorga</i> . Dritter Beitrag zur Pal. Russlands, p. 43, pl. vii, fig. 3,
1846. |
| — | — | <i>M'Coy</i> . British Pal. Fossils, p. 253, 1852. |

Spec. Char. Almost completely and regularly elongate-oval, much longer than wide; sides moderately convex; front much rounded; beaks bluntly acuminate; valves nearly equally and very gently convex; surface almost smooth to the naked eye, but under a lens marked with fine concentric lines of growth. Two specimens measured—

Length 7, width 4, depth 2 lines.

„ 4, „ 2 lines.

¹ Mr. Salter tells me that all Portlock's originals are to be found (with the original labels attached) in the Museum, London, arranged and ticketed by himself; and that there is an authentic set in the Museum at Stephen's Green, Dublin.

Obs. Prof. M'Coy identifies the shell under description with Pander's *P. longissima*; and it certainly very much resembles M. de Verneuil's figure of the Russian species. Mr. Salter, at p. 267 of his Appendix to Ramsay's 'Geology of North Wales,' unites M'Coy's *P. longissima* with his *L. ovata*.

Position and Locality. Through the kindness of Mr. H. Seeley, I have been enabled to draw the Cambridge Museum specimen described by Prof. M'Coy, which was found in the Bala limestone of Mynydd Fron Frys, five miles west of Chirk, North Wales. Much better and larger examples, agreeing still more closely with M. de Verneuil's figure of the Russian shell, were obtained by Mr. D. C. Davies from the Bala shale at Moelydd, in Wales, and by Mr. Prosser from beds of the same age at Ketch Bridge, near Llanfyllin. In Russia *L. longissima* was found by M. de Verneuil at Pavlosk and Baltischport; while Kutorga obtained his specimens at Pulkova. Pander figures only the anterior half of the shell.

(?) *LINGULA OBTUSA*, *Hall*. Pl. III, fig. 31.

LINGULA OBTUSA, *Hall*. Pal. New York, vol. i, p. 98, pl. xxx, fig. 7, 1847.

— — *M'Coy*. British Pal. Fossils, p. 253, 1852.

Spec. Char. Broadly ovate, moderately convex at the beaks, flattened towards the front, longer than wide, widest anteriorly; sides slightly convex; front rounded; beaks obtuse; surface almost smooth, or marked by a few concentric lines of growth.

Length (of the Cambridge Museum specimen) 7, width 6 lines.

Obs. Prof. M'Coy describes and identifies a single specimen, found in the Llandeilo flags (Lower Bala rock) of Llandeilo, Caermarthenshire, with the *L. obtusa* of Hall; and Mr. H. Seeley has enabled me to figure the specimen so described. I would not, however, from the inspection of a single example, venture to assert the identification to be correct: the specimen agrees pretty well with Hall's description and figure, although the beak is not quite so obtuse as in the American specimen, which came from the more shelly portion of the Trenton limestone of Middleville, Herkimer county.

(?) *LINGULA CURTA*, *Conrad*. Pl. III, fig. 33.

LINGULA CURTA, *Conrad*. Journal Nat. Science Phil., vol. viii, p. 266, pl. xv, fig. 12, 1842.

— — *Hall*. Pal. New York, vol. i, p. 97, pl. xxx, fig. 6, 1847.

— — *M'Coy*. British Pal. Foss., p. 251, 1852.

Spec. Char. Very obtusely ovate; sides and front broadly rounded; beak small and acuminate; valves very slightly convex, or flattened and marked by concentric lines of growth.

Length 5, width 4 lines.

Obs. One specimen in the Cambridge Museum, from the "Calcareous [Lower] Bala flags of Wellfield, Builth," was described and identified by Prof. M'Coy with the American *L. curta* of Conrad. I have again, thanks to Mr. H. Seeley, been able to figure the specimen so described by Prof. M'Coy. It certainly agrees pretty well with Prof. Hall's figure and description; but from a single specimen I would not venture to assert the British shell to be specifically the same as that from the Utica slate and Trenton limestone of Middleville and East Canada Creek, or of Carlisle (Pa.), N. America.

The identification of this and the preceding two species is, therefore, here given solely on Prof. M'Coy's authority. Mr. Salter is of opinion that this is the young of the common Llandeilo-flag fossil, *L. attenuata*, Sow.

(?) *LINGULA PYGMÆA*, *Salter*. Pl. II, fig. 8.

LINGULA PYGMÆA, *Salter*. Quarterly Journal Geol. Soc., vol. xxi, p. 101, 1865.

Spec. Char. Shell minute, thin, subcylindrical, gibbous; beak somewhat obtuse; anterior margin truncate; surface finely striated transversely.

Length $\frac{1}{15}$ th, width $\frac{1}{20}$ th inch. (*Salter*.)

Obs. Not having myself seen a specimen of this minute shell, I must be content with reproducing Mr. Salter's description and figure. Dr. Hall informs me that *L. pygmæa* was obtained from the black shales, which correspond with the uppermost division of the Lingula-flag formation.

Locality. Malvern Hills.

LINGULA (?) *SALTERI*, *Dav.* Pl. I, figs. 27—29.

Spec. Char. Longitudinally oval or ovate, widest anteriorly or at about the middle, the sides and front forming a regular curve or half circle, which continues, but with less convexity, to the extremity of the beaks, the junctions of the slopes at the beaks forming an obtuse angle; valves moderately convex, most so at a little distance from the extremity of the beaks; surface marked with concentric lines of growth, more deeply indented at intervals. Two specimens measured—

Length 24, width 22 lines.

„ 19, „ 18 „

Obs. Whether this shell be a *Lingula* or an *Obolus* is a question which the material at my command will not enable me correctly to determine, for none of the specimens showed any portions of their interior. It much resembles *Lingula exilis*, Hall ('Thirteenth Annual Report of the Regents on the State Cabinet,' p. 76, New York, 1860), a shell occurring in the Hamilton group and Marcellus shale of Bridgewater, New York.

Prof. Hall's specimens measured about an inch in length, while an example of *L. Salteri*, found by Mr. Vicary, had attained two inches in length; it, however, remains a question whether the American and British specimens may not belong to a single species.

L. Salteri occurs in the Budleigh Salterton pebbles, and is supposed to be of the same age as *Lingula Lesueuri*, a fossil of the "Armorican sandstone" of Normandy, which has been assigned by Marie Rouault and other palæontologists, upon good data, to the Lower Silurian series.

LINGULA (?) LEVIS, *Salter*, 1865. Pl. III, figs. 54—58.

LINGULA LEVIS, *Salter*. *Siluria*, p. 543, 1859.

LINGULELLA — *Salter*. *Memoirs of the Geological Survey of Great Britain*, vol. iii, p. 334, fig. 11, 1866.

Spec. Char. Broad-ovate, longer than wide, depressed; beak pointed, its slopes combining gradually with the lateral sides; front gently rounded; surface sharply marked with fine concentric striæ.

Length 4, breadth $3\frac{1}{2}$ lines.

Obs. Almost every specimen I have seen of this shell is more or less distorted, and, consequently, but little can be said with certainty of its specific characters. Mr. Salter informs us, however, that it is a smaller and rounder form than *L. Davisii*, and that interiorly there exists in the beak a short groove for the passage of the pedicle (see figs. 53 and 55); the central protractor muscles fill a narrow angular space, which is strongly bordered on each side. I must, however, remark that a specimen in the Museum of Practical Geology shows the interior (Pl. III, fig. 57) to possess characters so similar to those of *Lingula* proper that I provisionally place it with the last-named genus.

Position and Locality. Mr. Salter discovered his species in the Lower and Upper Tremadoc rocks of the Portmadoc district; very rarely in the higher beds of the Lingula-flags.

It occurs in the Upper Lingula-flags, near Tremadoc; doubtful. In the Lower Tremadoc of Wern; Borthwood; Trwyn-y-Iago; Cefn Cyfarnedd, east of Pontnant-y-Ladron, near Taihirion, on the Bala Road from Ffestiniog, &c. Here it is a common species.

In the Upper Tremadoc, under-Moel-y-gest; Garth, &c.

Genus or Subgenus—LINGULELLA, Salter, 1861.

Memoirs Geol. Survey of Great Britain, vol. iii, p. 333, 1866.

The characters upon which this genus (?) has been founded appear to me to require further examination, for the only character at present known which would distinguish it from *Lingula* seems to consist in a channel of the hinge-margin for the passage of a very narrow pedicle; and this has been observed, to my knowledge, in one or two specimens only. The muscular and other impressions are remarkably faint and indistinct, even in the best-preserved specimens I have seen; and the visceral surface of the shell in one specimen was covered with pits (Pl. IV, fig. 16) or rough prominences on the cast (figs. 14 and 15).

The name *Lingulella* was first introduced about 1861, with the late Dr. P. S. Woodward's full consent; and the name appears at p. 9 of Sir Roderick Murchison's Address to the Geological Section of the British Association, Manchester, 1861; but it is only in Mr. Salter's Appendix to the 'Memoir on the Geology of North Wales' that the genus is for the first time described:

"Nearly equivalve, broad-oblong, the ventral valve pointed, with a distinct pedicle-groove. Muscular scars strong, nearly as in *Obolus*, but the pair of anterior retractors (c) are more linear [than in *Obolus*], and the sliding muscles (b) small, and not quite external, as in *Obolus*." (I have reproduced Mr. Salter's figure, see Pl. IV, fig. 3, but cannot say that the muscular impressions are clearly defined.) "The form, as well as what we know of the interior, is more like *Lingula* than *Obolus*; but the arrangement of the muscles in the only valve we possess of the interior (ventral?) is more like that in *Obolus*. The anterior retractors diverge widely, and are linear, the central (protractors?) come nearly down to them, and the external (or sliding?) muscles are too small and too near the centre for *Obolus*. The description of *Obolella*, Billings, 'Geol. Survey Reports,' Canada, 1861, 1862, a good deal recalls this; but his later figures show a very different set of muscular scars."¹

Although I have examined a very great many specimens of the typical species *L. Davisii*, of M'Coy, none satisfactorily showed internal characters; good interiors should, therefore, be sought for and studied.

¹ Mr. Salter's description of the muscles of *Lingula* or *Lingulella*, adopted from Woodward's 'Manual,' is not quite the same as that proposed by Mr. Hancock and adopted in my 'Monograph of Carboniferous Brachiopoda,' pp. 199—205.

LINGULELLA DAVISII, M'Coy (sp.). Pl. IV, figs. 1—16.

Lingula, Davis, Quarterly Journal Geol. Soc., vol. ii, p. 71, 1846; Sedgwick, ib., vol. iii, pp. 140, 143, 147, 1847.

LINGULA DAVISII, M'Coy. Ann. and Mag. Nat. Hist., 2nd ser., vol. viii, p. 405; and British Palæozoic Fossils, p. 252, pl. i L, fig. 7; also, when distorted, *Tellinomya lingulæcomes*, ib., pl. i K, fig. 18, 1852.

— OVATA, M'Coy (parte). Brit. Pal. Foss., p. 254, i L, fig. 6 (non *L. ovata*, M'Coy), 1852.

— DAVISII, Salter. Siluria, p. 53, Woodcut foss. 9, fig. 11, 1859.

LINGULELLA — Salter. Memoirs of the Geological Survey of Great Britain, vol. iii, p. 333, pl. ii, figs. 7—12, pl. iv, fig. 14, 1866.

Spec. Char. Depressed, ovato-pentagonal, longer than wide; lateral sides almost parallel; front nearly straight, or but slightly rounded; beaks obtusely angular, the slopes being almost straight; valves about equal, and very slightly convex; hinge-area in the ventral valve flat and rather broad, with a narrow groove in the middle. The surface of the area, in the vicinity of the fissure, is horizontally striated and marked out by slanting lines. Internal surface marked with numerous pits, especially near the hinge-line. External surface covered with fine, sharp, concentric striæ, or imbricating laminæ. A large species; one example measures 13 lines in length by 10 in width.

Obs. Prof. M'Coy and Mr. Salter have both bestowed much attention to the study of this species; they have also given us good descriptions, as far as the material in their possession would permit, of its external as well as of its interior characters. Although extremely abundant in the localities where it occurs, the shell is usually, or I might say almost always, more or less flattened and distorted, compressed or elongated, from the effects of pressure and cleavage, and, consequently, but rarely shows its true shape; in some of these conditions it has even been mistaken by Prof. M'Coy for a species of *Tellinomya*—*T. lingulæcomes* [Salter]. Prof. M'Coy states that its external surface is marked "with numerous faint, concentric, rather wide, sub-angular undulations of growth, accompanied by irregular, concentric, imbricating laminæ; striæ ten in one line on the exterior of the shell; no trace of longitudinal external striæ, but on the internal cast a few faint, obsolete, flattened, fibrous radiations, observable with the lens; . . . this curiously wide satchel-shaped *Lingula* is the species discovered by Mr. Davis in such profusion in the Lingula-slates near Tremadoc. . . . The British species most allied to this is the *L. attenuata*, Sow., which, however, is easily distinguished by its much longer, trigonal, retrally narrowed form, rising from the gradual passage of the sides into the posterior lateral margins (without angulation), the very prominent, narrow, gibbous form of the beaks, &c. The substance of the shell is very thin, and the traces I have seen, apparently of the mesial ridge, extend little more than one third the length of the shell.

The shell is usually found in the state of cast, so that the surface-markings of the shell are not always sharply visible." (It is, however, often perfect.—J. W. S.)

Position and Locality. Of all the fossils found in the Lingula-flags this appears to be the most abundant, and especially so in the lower and middle portions, being quite rare in the upper part; but, as observed by Mr. Salter, it occurs of nearly full size again in the sandy beds of the Upper Tremadoc slate. Indeed, the designation of *Lingula-flags* was first applied (by Professor Sedgwick) in consequence of Mr. Davis' discovery of *L. Davisii* in these rocks near Tremadoc in 1845, for this shell was found to be so characteristic that it gave the name to the formation. It is, indeed, one of the oldest Brachiopoda hitherto discovered; but Mr. Salter informs me that other species of *Lingula* or *Lingulella* occur even 4000 feet lower down in the rock-series.

In the appendix to Prof. Ramsay's memoir Mr. Salter gives the following localities:

Lower Lingula-flags (North Wales)—Carnedd Filiast, Bangor; Marchlyn-mawr, Llanberis; Tremadoc; Ffestiniog; Dolgelly; everywhere in the middle band of the Lingula-flags, rare in the lower black slates, at Maentwrog. In the Survey Collection there are many specimens from the Lower Lingula-flags of Pen-y-Bryn, five miles north of Dolgelly, Bryn-mawr House, &c.; near Nant-y-Groes, to the west of Bala, North Wales, and other localities. In South Wales—Whitesand Bay, near St. David's Head, Pembroke-shire.¹ Abundant in the Upper Tremadoc beds, at Deudraeth; Garth. Prof. M'Coy states that it is extremely abundant in the Lingula-slates south of Penmorfa; Tremadoc, North Wales; and he also quotes it from the Bala limestone of Coniston, Lancashire; but from these Bala schists and limestones I have not seen specimens, and Mr. Salter tells me it is the true *L. ovata* that is meant. And as I have already had occasion to observe, in the description of *L. ovata*, I consider the specimen so named and figured by M'Coy ('Br. Pal. Fos.,' pl. 1 L, fig. 6), "from the Lingula-slates of Penmorfa," to be only an elongated specimen of *L. Davisii*, and so shaped from the effects of cleavage. It occurs of every possible form.

¹ Mr. Salter observes, at p. 249 of his Appendix, that the range and persistence of this *Lingulella* (or *Lingula*) is remarkable; it is found in quantity everywhere throughout the Tremadoc country and the vale of Ffestiniog, and through the wild moory ground as far east as Llyn Dywarchen, where it was detected by Prof. Ramsay. Mr. Salter found it there in plenty in 1853, and also at Pont Nant-y-Lladron, on the Bala road. East of that line the hard Lingula-flags do not occur; but, followed to the south-west and south, it has been found by the Surveyors everywhere to hold the same horizon, that is to say, in the middle or quartzose series of the Lingula-flags. He has found it near the base of the slates, in company with Trilobites, near the Maentwrog waterfall, as above noticed; but it was small and ill-developed there, as it is also in the beds which overlie the Lingula-beds; yet, strange to say, it reappears in the upper portions of the next or overlying formation, of nearly its full size and character. We must also refer the reader to a very interesting paper by Mr. Salter, "On the Lowest Fossiliferous Beds of North Wales," published in the 'Report of the British Association for the Advancement of Science' for 1852 (Transact Sections), wherein the author gives many details with reference to the geological position of the beds which contain *Lingula Davisii*, and which were, even at that time, determined by M. Barrande to be equivalents of his Bohemian "Etage C."

In the Lower Silurian shales of Bellewstown, County Meath, Ireland, we find some flattened distorted *Lingulæ*, which may, perhaps, belong to the species under description; we have given a figure of them in our plate. This species probably occurs in the slates of the age of the *Lingula*-flags in several parts of the northern hemisphere, and Mr. Salter refers it, but with some uncertainty, to the Alum-slates of Christiania (Kjerulf's Collection in the Museum of Practical Geology).

Genus—*OBOLUS*, *Eichwald*, 1829.

Ref. Eichwald, 'Zoologia Specialis,' vol. i, p. 274.—*UNGULA*, Pander, 'Beiträge zur Geognosie des Russischen Reich.,' 1830.—*ORTHIS*, von Buch (pars).—*AULONOTRETA*, Kutorga, 'Ueber die Siphonotretæ,' &c., 1847.—*OBOLUS*, Morris, 'Annals and Mag. of Nat. Hist.,' vol. iv, p. 319, 1849. Davidson's 'Monograph Brit. Foss. Brach.,' vol. i, General Introduction, p. 135.

As I have already described this genus so far as our still incomplete knowledge of its structure will admit, all that need be repeated is, that it will require to be maintained as a section of the Family *Lingulidæ*.

OBOLUS DAVIDSONI, *Salter*. Pl. IV, figs. 30—39.

OBOLUS DAVIDSONI, *Salter*, MS. Davidson's Monogr. vol. i, General [Introduction, p. 136, figs. 54, 55, 56, 1853.

— — *Woodward*. Manual of the Mollusca, p. 240, 1856.

— — *Salter*, Murchison's Siluria, 2nd ed., p. 543, 1859.

— — *Lindström*. Silurian Brachiopoda of Gothland; Ofversigt af K. Vet. Akad. Förhandl., p. 375, 1860.

Spec. Char. Transversely oval, sub-equivalve, valves almost equally and moderately convex. Ventral valve with a very short obtusely pointed beak. In the interior the hinge-margin of the ventral valve is thickened with a small groove in its centre, a narrow, slightly elevated, longitudinal ridge extending also to a short distance inwards, with a small oval muscular impression on either side close under the hinge-area; towards the middle of the shell are two larger obliquely placed oval scars, separated by a tongue-shaped depression, which extends to some distance further down and is slightly raised from the bottom of the valve. In the interior of the dorsal valve two small horizontal oval impressions are also visible close under the narrow hinge-margin, and towards the middle of the valve are two oblique muscular scars, also separated by a tongue-shaped

space, which is not prolonged further than the anterior margin of the impressions. Surface smooth, marked with concentric lines of growth; shell-structure calcareo-corneous.

Length 14, width 16, depth 5 lines.

Obs. Prior to 1853 internal casts of this curious fossil had been found very abundantly in the Wenlock shales near Dudley and Walsall, as well as in those of other localities, but palæontologists were at a loss to determine the genus to which they belonged, and my friend Mr. Salter asked me to describe them for him. Having received about that period an extensive series of Russian examples of *Obolus Apollinis* and *O. sculptus*, I recognised that our English casts were referable to the Russian genus, and that they were the largest representatives of *Obolus* known up to that period.¹

Mr. Salter is of opinion that the specimens found near Walsall and elsewhere really belong to two or three distinct species; but as Dr. S. P. Woodward and myself felt at the time very uncertain whether sufficiently distinctive characters could be found to separate them specifically, I preferred describing them provisionally as named varieties of *O. Davidsoni*; and, indeed, there seems to exist every passage in shape between the typical form of *O. Davidsoni* and *O. transversus*. In Pl. IV. I have figured many specimens, to show how much their interior markings vary in detail.

Position and Locality. Wenlock shales, Rushall Canal, near Walsall, Dudley, and the Wenlock limestone of Benthall Edge; it has also been found in the Wenlock shales of the Malvern and Ledbury Tunnel (Mus. P. Geol.). In Ireland it occurs in Upper Silurian shales at Ferriter's Cove; and imperfect specimens from that locality may be seen in the Museum of the Geological Survey, Dublin. It has also been obtained by Prof. Lindström in the Upper Silurian limestone of Gothland and Färo.

Var. TRANSVERSUS, *Salter*. Pl. V, figs. 1—6.

OBOLUS TRANSVERSUS, *Salter*, MS. Davidson's Monogr., vol. i, General Introduction, p. 136, fig. 53, 1853.

Shell transversely oval, depressed. Length 19, width 28 lines.

Obs. In some specimens of *Obolus Davidsoni* the posterior margin is very obtuse and almost straight; the surface smooth and marked with concentric lines of growth; and on a cast found by Mr. Mushen, and figured in our plate there exist a number of spine-like impressions, which would lead us to suppose that the surface had been originally covered with spines.

Position and Locality. This variety occurs in the same localities as the preceding, but is most abundant in the Wenlock shale of Parkes' Hall, near Dudley, at Walsall, and also in the Woolhope limestone of Malvern. (Mus. Prac. Geol., and many cabinets.)

¹ Some years later Mr. Billings discovered in Canada a very interesting large species of the same genus, to which he applied the specific denomination of *O. Canadensis* ('Geol. Survey of Canada,' 1857).

Var. *WOODWARDII*, *Salter*. Pl. V, figs. 7, 8.

OBOLUS WOODWARDII, *Salter*, MS. (Mus. P. Geology).

Shell transversely oval; posterior marginal almost straight (?); surface marked with concentric lines of growth. Length 22, width 27 lines.

Obs. Certain undetermined differences are observable in an imperfect cast; but the material at command is very incomplete.

Position and Locality. Wenlock limestone, Dormington Wood, Woolhope, and Wenlock shales near Dudley. Both specimens may be seen in the Museum of Practical Geology.

Genus—*OBOLELLA*, *Billings*, 1861.

Ref. 'Geology of Canada,' "Palæozoic Fossils," vol. i, p. 7, 1861.

Not having been able to study the interior characters in this genus, all I can do is to reproduce Mr. Billings' description.

"*Generic Characters.* Shell ovate, circular, or sub-quadrate, convex or plano-convex. Ventral valve with a false area, which is sometimes minute, and usually grooved for the passage of the peduncle. Dorsal valve either with or without an area. Muscular impressions in the ventral valve four, one pair in front of the beak near the middle or in the upper half of the shell, and the others situated one on each side, near the cardinal edge. Shell calcareous; surface concentrically striated, sometimes with thin, expanded, lamellose ridges.

"In general form these shells somewhat resemble *Obolus*, but the arrangement of the muscular impressions is different. In *Obolus* the two central scars have their smaller extremities directed downwards and converging towards each other, but in this genus the arrangement is exactly the reverse."

Six Canadian species are described by Mr. Billings; but, unfortunately, the shells are small, and the figures showing the interior markings not sufficiently distinct. Nor do our British specimens help us out in this particular. Messrs. Meek and Hayden, while describing their *Obolella nana*, observe that "since seeing Mr. Billings' figures of his genus *Obolella*, recently published, they are fully satisfied that he is right in separating these shells from the genus *Obolus*."

It is not, however, perfectly certain that any of our hitherto discovered British species agree with Mr. Billings' genus, although two or three have been referred to it.

OBOLELLA ? PLUMBEA, *Salter*. Pl. IV, figs. 20—27.

LINGULA PLUMBEA, *Salter*, *Siluria*, 2nd ed., p. 50, Foss. 8, fig. 1, 1859.

OBOLELLA — *Id.*, *Memoirs of the Geological Survey of Great Britain*, vol. iii, p. 334, pl. xi B, fig. 10, 1865.

Spec. Char. Broadly sub-triangular, as wide or wider than long, compressed laterally, and anteriorly broadly rounded, posteriorly or retrally acuminate; beak pointed; valves almost equally deep and very slightly convex; surface smooth, polished, and marked with many concentric lines of growth, and fine radiating striæ. Two specimens measured—

Length 8, width 8 lines.

„ 8 10 „

Obs. Mr. Salter informs us that this is a remarkably broad species; but in general the width does not appear to have very much exceeded the length: we are also told that the muscular scars are remarkably strong and clearly defined, and are less divided or bilobed than even in *O. pretiosa*, Billings, in which species this undivided character is most conspicuous; Mr. Salter is therefore of opinion that *O. plumbea* will probably in future form the type of a new genus, distinguished particularly by this union of the muscular scars; and he has endeavoured to indicate this by the sectional name of *Monobolina*, the muscular scars being united closely along the central line. I have seen several fine specimens of the exterior of this shell; and I have figured the only two internal casts with which I am acquainted, showing muscular impressions; these also were used by Mr. Salter in making his descriptions.¹ It is possible that *Obolella Salteri*, Holl, may be nothing more than a synonym of the shell under description.

Position and Locality. This species occurs abundantly in the *Lower Llandeilo*, west of the Stiper Stones, Shropshire, particularly at White Grit Mine, Shelve; it is also found at Ty Obry, two miles east of Portmadoc. In the Museum of the Geological Survey some specimens are labelled Hellpool, Wyeford, Builth. This is “Upper Llandeilo;” and it may be a mistake.

? OBOLELLA SALTERI. Pl. IV, figs. 28, 29.

OBOLELLA SALTERI, *Holl*. *Quarterly Journal Geol. Soc.*, vol. xxi, pp. 101 and 102, fig. 9, 1864.

This shell is described by Dr. Holl as “compressed, sub-trigonal to nearly round,

¹ *O. plumbea* bears also some resemblance to *Obolella chromatica*, Billings, a species which in Canada occurs in limestone of the Potsdam group at the Anse au Loup, on the north shore of the Straits of Belle Isle.

rather broader than long; shell thin; surface grooved concentrically by a few inequidistant, strongly marked lines of growth, and by numerous finer lines, which are distinct only on the sides of the shell. Length usually about $\frac{1}{3}$ inch, width slightly more."

Obs. In external shape, the only specimen of the shell I have seen (the outlines of which are given in Dr. Holl's paper) very strongly reminds me of *O. plumbea*. It was found by Dr. Holl in the black shales, or upper division of the Lingula-beds, near Coalhill, at the east end of the Malverns. As no species are common to the new formations, "Lower Llandeilo" and "Lingula-flags," we may, perhaps, keep them distinct.

Mr. Salter believes that one or two more species of *Obolella* occur in the Lower Llandeilo of Wales; and of these he gives figures, without names, in the Appendix to Prof. Ramsay's 'Memoir on the Geology of North Wales;' they are from the "Lower Llandeilo or Arenig Rocks" of Llanfaelrhys, South Caernarvonshire. The specimens are too obscure to warrant our reproducing them; and Mr. Salter figures them only to draw attention to a rare genus.

OBOLELLA? PHILLIPSII, Holl. Pl. IV, figs. 17—19.

OBOLELLA PHILLIPSII, Holl. Quarterly Journal Geol. Soc., vol. xxi, pp. 101, 102, figs. 10, *a, b*, 1864.

Spec. Char. Shell small, semicircular; hinge-line nearly straight, as broad as the breadth of the shell, or slightly shorter. Dorsal valve very moderately convex or depressed near the angles; ventral valve convex at the beak, which is slightly bent backwards, obtusely pointed, depressed near the margin. Surface marked with numerous fine concentric striæ, which are at intervals divided by a deeper line. Interior unknown.

Length 4, breadth 5, depth 1 line.

Obs. The species to which this *Obolella?* is nearly allied, or which it most resembles, is *Obolella (Kutorgina) cingulata*, Billings;¹ but the Canadian is many times larger than our British shell, and differs in several other particulars. Unfortunately, all the specimens

¹ 'Geology of Canada,' "Palæozoic Fossils," vol. i, p. 8, 1861, Mr. Billings informs us that his *O. cingulata* was obtained at the Anse au Loup, on the north shore of the Straits of Belle Isle, in limestone of the Potsdam group; also abundantly, in the condition of casts, a mile and a half east of Swanton, in Vermont: and in a foot-note to p. 9 the same author observes—"Since the above was written I have examined many casts of the interior of this species, and am inclined to the opinion that it is generically distinct from *Obolella chromatica*. From the very considerable elevation of the beak, the dorsal valve must have had an area, and probably a foramen. In one specimen there are two large oval impressions, faintly impressed, but still distinctly visible. There is no trace of the lateral scars; and the form, notwithstanding the characters of the surface, conveys the idea of an *Orthisina*. Should, upon further examination, my suspicions turn out to be well founded, I shall call the genus KUTORGINA, after the celebrated European naturalist Kutorga. It is not quite certain which is the ventral or which is the dorsal valve." It appears to me very doubtful if *Obolella Phillipsii* belongs really to *Obolella*; probably it must be placed in the group that will be typified by *O. (Kutorgina) cingulata*.

hitherto found are in an incomplete condition, and the absence of all knowledge with reference to its interior must leave us still uncertain whether it belongs to the same genus or sub-genus as *O. plumbea*.

Position and Locality. Dr. Holl states, at p. 89 of his very interesting memoir on the Malvern Hills, that *O. Phillipsii* is found in the felspathic Hollybush sandstones of the Malvern Hills, representing the middle division of the Lingula-beds of North Wales.

FAMILY—DISCINIDÆ.

This family is composed of several genera and sub-genera; but in our British Silurian rocks *Discina* (including *Trematis* and *Orbiculoidea*) only have been hitherto discovered. In all the species the shell was attached to marine objects or rocks by a pedicle passing through an aperture or foramen in the ventral valve.

Genus—DISCINA, *Lamarck*.

Syn. *Orbicula* of Sowerby and of many other authors (not of Cuvier).

Ref. Davidson's 'General Introduction,' p. 126. The anatomical structure of *Discina*, as regards its muscular and other internal arrangements, has not been hitherto sufficiently examined. *Trematis* does not seem to possess characters of sufficient importance to warrant its positive admission as a distinct genus. Our reasons for this are stated under *Discina (Trematis) punctata*. The internal characters of *Orbiculoidea* have not yet been discovered; still, we retain the name provisionally as a sub-genus of *Discina*, with doubly convex valves.

DISCINA RUGATA, *Sow.* (sp.) Pl. V, figs. 9—18.

- | | | |
|----------|---------|--|
| ORBICULA | RUGATA, | <i>Sow.</i> , in Murchison's Sil. System, pl. v, fig. 11, 1839. |
| — | — | <i>Dav.</i> Bull. Soc. Géol. France, 2nd ser., vol. v, p. 334, 1848. |
| DISCINA | — | <i>M'Coy.</i> British Palæozoic Fossils, p. 190, 1852. |
| — | — | <i>Salter.</i> Siluria, 2nd ed., pl. xx, figs. 1, 2, 1859. |

Spec. Char. Nearly orbicular, sometimes a little longer than wide or longitudinally oval and slightly narrowed posteriorly. Upper or free valve of a low conical or limpet-like shape. Vertex situated at variable distances between one third and one fifth the

length from the posterior margin. Surface marked with small interrupted, more or less close, concentric ridges, separated from each other by interspaces of greater or smaller breadth; lower or attached valve depressed, slightly convex near its apex, the oval fissure or perforation extending from near the centre of the valve to a short distance from the posterior margin. Surface as in the free valve, but a little more regularly marked. Three specimens measured—

Length 9, breadth 9 lines.

„	6½	„	7	„
„	7	„	6	„

Obs. In external shape *Discina perrugata* seems to me to agree closely with *Discina rugata*; and it is evident that the eminent Irish palæontologist has given the description from the *single* specimen he has represented, for (as may be seen from the figures in our plate) both it and *D. rugata* present the same dimensions and shapes, as well as distances of the apex from the margin; but as Mr. Salter considers them distinct on account of a difference in the concentric striation, which he regards as being regularly wrinkled in *D. perrugata*, M'Coy, and not like that of *D. rugata*, Sow., I have provisionally kept them under distinct heads. The shell-substance of *D. rugata* is distinctly corneous, and not punctured, as erroneously supposed by D'Orbigny.

In Pl. IV will be found typical figures of *Discina rugata*, Sow., as well as of *D. perrugata*.

Position and Locality. Sowerby, in Murchison's 'Silurian System,' enumerates the following localities for his *D. rugata*:

“Ludlow promontory, viz., Richard's Castle; Bradnor Hill, Kington; Bagbarrow Hill; Pain's Castle, Radnorshire, very abundant:” all in the Upper Ludlow rock.

Phillips furnishes the following distribution, from the Upper Ludlow and Aymestry rock:

Malvern district.—Overley, Hale's End, Mathon Coomb, Frith Hall Court; Upper Ludlow rock.

Abberley district.—Ankerdine Hill, Aymestry limestone; Barrell Hill, Hole Farm, Wallgrove, Hillside Farm; Upper Ludlow rock.

Woolhope district.—Welsh Court, Shucknall Farm, Shucknall Hill, The Wonder, Old Sutton, Perton, &c., north-east of Pilliard's Barn, Bodenham; Upper Ludlow rock, and Aymestry limestone.

May Hill district.—Longhope, &c., Upper Ludlow rock.

Tortworth district.—Pyrton Passage, Upper Ludlow rock.

Usk district.—Usk Castle, Upper Ludlow rock; Llanbadoc, Aymestry limestone.

Builth district.—Henllyn, Pencarreg, Upper Ludlow rock.

In his work on 'British Palæozoic Fossils' Prof. M'Coy adds that *D. rugata* is common in the hard Upper Ludlow rock of Benson Knot, Kendal, Westmoreland; in the same rock at the north end of Potter's Fell, Kendal; at Burton and Brockton, near

Ludlow, Shropshire, &c. It has often been found in Wenlock shale near Dudley, and it occurs also in the Upper Ludlow rock, Ledbury. Mr. Lightbody has collected *D. rugata* in the Upper Ludlow of Whitecliffe and Sunny Bank, near Ludlow, and in the Lower Ludlow of Church Hill, where it is associated with *Lingula lata*.

? *DISCINA PERRUGATA*, *M'Coy*. Pl. V, figs. 19—24.

ORBICULA PERRUGATA, *M'Coy*. Synopsis of the Silurian Fossils of Ireland, p. 24, pl. iii, fig. 2, 1846.

Prof. M'Coy describes this species (?) as "nearly orbicular, depressed; about one sixth wider than long; apex one third the diameter from the margin; surface strongly wrinkled concentrically." He adds, "This species is distinguished from the *O. rugata*, Sow., and *O. plana*, Münster., by the greater distance of the apex from the margin in the present shell; and from the *O. subrugata*, Münster., by the strong concentric wrinkles. It most resembles the Carboniferous *O. nitida*, Phil., but is much more depressed and strongly wrinkled."

Locality. *D. perrugata* is common in the Caradoc beds of Desertcreat, County Tyrone; in rocks of the same age near the Chair of Kildare; at Cong, County Galway; Duncannon, County Wexford, &c. In Scotland it occurs at Balclatchie, Girvan Valley, Ayrshire.

(?) *DISCINA MORRISII*, *Dav.* Pl. VII, figs. 10—12.

ORBICULA MORRISII, *Dav.* Bulletin Soc. Géol. de France, 2nd ser., vol. v, p. 334, pl. iii, fig. 47.

DISCINA — *M'Coy*. British Palæozoic Fossils, p. 190.

Spec. Char. Almost circular, or slightly elongated oval; free valve conoidal or limpet-like, and moderately elevated, the incurved vertex about one third the length from the posterior margin; surface smooth, marked here and there only by a few very slightly defined lines of growth. "Lower or attached valve slightly concave at the margins and at the anterior half, tumid towards the opening (fissure), which is very broad, oval, half its length from the posterior margin, the intervening space being about one sixth the entire length" (M'Coy). Two specimens measured—

Length 5, width 5 lines.

„ 7, „ 6 „

Obs. My materials in connection with this *Discina* have not been sufficient, and consequently I am not quite certain as to its specific value. It appears to be

more convex than the Lower Silurian form, *D. oblongata*; but this does not always hold good, for some Ayrshire examples of *D. oblongata* possess as much elevation as any of *D. Morrisii* I have yet seen. Never having obtained the lower or attached valve, I have transcribed the description given of it from a specimen in the Woodwardian Museum, by Prof. M'Coy, in his 'British Pal. Fossils.'

Position and Locality. *D. Morrisii* occurs in the Wenlock shale and limestone of Dudley; in the Aymestry limestone of Sedgley; and in the Lower Ludlow of Leintwardine, Shropshire.

DISCINA OBLONGATA, *Portlock* (sp.) Pl. VII, figs. 1—9.

ORBICULA OBLONGATA, *Portlock*. Report Geology of Londonderry, &c., p. 445, pl. xxxii, fig. 13, 1843.

— LÆVIGATA ? (*Münster*), *Portlock*. Ibid., p. 445, pl. xxxii, figs. 11, 12.

— SUB-ROTUNDA, *Portlock*. Ibid., pl. xxxii, fig. 10.

— OBLONGATA, *M'Coy*. Synopsis of the Silurian Fossils of Ireland, p. 24, 1846.

Spec. Char. Nearly orbicular, or elongated oval. Upper or free valve moderately convex, conoidal, and more or less elevated, the incurved pointed vertex situated at a short distance from the posterior margin. Surface smooth, marked only here and there by a few lines of growth. Lower valve unknown. Two specimens measured—

Length 9, width 9, height 2 lines.

„ 8, „ 6, „ 2 „

Obs. After an attentive examination of Portlock's original examples of his *O. lævigata* Münster?, *O. oblongata*, and *O. subrotunda*, Portlock, I arrived at the conclusion that they were all slight modifications of a single species: all are derived from the same rock and locality, viz., Desertcreat, County Tyrone, Ireland. General Portlock thought he could identify, but with some uncertainty, one of his specimens with the *Orbicula lævigata* of Münster, 'Beiträge' ("Die Versteinerungen der Uebergangskalkes mit Clymenien und Orthoceratiten von Oberfranken"), vol iii, p. 80, tab. xiv, fig. 21, 1840. Münster describes his shell, which was small, as circular, highest towards the beak, which is only slightly arched, and at the outer margin depressed; surface smooth, with hardly any lines of growth. His figure, however, does not leave in my mind a certainty that Portlock's large example referred to *O. lævigata* belongs in reality to that species; and as it has not been possible for me to obtain a sight of the German type, I propose to make use of one of Portlock's designations for the species under description. It may also be observed that in the same year in which Münster gave the name of *lævigata* to a German palæozoic *Discina*, Deshayes applied the same designation to one of Leymerie's French

Cretaceous species, and consequently a question might arise as to which form may claim the name of *lævigata*.

Discina oblongata, like all its congeners, varies considerably in shape, some specimens being more circular or more elongated than others; and the free valve is also more elevated or conoidal in some specimens than in others; thus, in the Caradoc beds of Shropshire and Ayrshire, where the species occurs, some examples show much more elevation than what we perceive in Portlock's typical specimens.

Position and Locality. In Ireland *D. oblongata* and its varieties, *lævigata* and *subrotunda*, were found in the coarse gritty Caradoc schists at Desertcreat; in sandy schists at Bardahessiagh, in the County Tyrone; and in slates at Tirnaskea, Co. Pomeroy. It has also been met with in the same beds at Tramore, County Waterford.

In England Mr. Davies has found it in the Caradoc beds of South Shropshire (upper beds only—J. W. S.). It occurs also at Llanfyllin, Montgomeryshire.

In Scotland a variety is not rare in the Caradoc of the Girvan Valley in Ayrshire.

? *DISCINA*? *VICARYI*, *Dav.* Pl. VII, fig. 13.

Spec. Char. Free or upper valve ovate, longer than wide, narrowed posteriorly, broadly rounded anteriorly, conoidal and moderately elevated; vertex slightly incurved, so that its extremity is situated almost vertically above the middle of the posterior margin or a little incurved forward; surface smooth (?); lower or attached valve not known.

Length 8, width 7 lines.

Obs. Two specimens in the state of casts of the upper or free valve of this *Discina* (?) were found by Mr. Vicary in the red sandstone pebbles of Budleigh Salterton, in Devonshire. Not possessing the lower or attached valve, I must leave the description and identification very incomplete and provisional.

It is also uncertain whether this shell belongs to the Lower Silurian, since species of that period are mixed up in the locality with shells evidently of Devonian age. It is also at times difficult to distinguish certain species of *Discina* (?) from others of *Metoptoma*; for instance, *M. estella* of Billings bears some resemblance to our *D. Vicaryi*; but this last is less conical than is the Canadian Gasteropod. [Mr. Salter would provisionally refer all the so-called *Metoptomæ* and *Capuli* from the Lowest Silurian or Potsdam groups to *Discinidæ*; and tells me that he has some such from his new 'Menævian' group.]

DISCINA STRIATA, *Sow.* (sp.) Pl. VI, figs. 1—4.

ORBICULA STRIATA, *Sow.* Silurian System, tab. v, fig. 21, 1839; Siluria, pl. xx, fig. 3, 1859.

DISCINA — *M'Coy.* British Pal. Fossils, p. 191, 1852.

Spec. Char. Usually transversely oval, sometimes longer than wide; upper or free valve moderately and uniformly convex; no defined apex, the posterior portion of the valve being evenly convex up to the margin. Surface marked with numerous fine, radiating, raised, sub-equal, thread-like striæ, with interspaces of about equal width, the surface being also crossed by numerous much finer concentric lines. The raised striæ radiate from the middle of the posterior margin, and increase in number here and there by the interpolation of additional ribs, some of which appear also to bifurcate. The lower or perforated valve is very much flattened, slightly raised only near the middle, between the centre of the valve and of its posterior margin; the slit is longitudinally oval, rather wide, and extending from near the centre of the valve to its posterior margin; surface ornamented with numerous fine radiating striæ, with wider interspaces, the entire surface being also very finely concentrically striated. Interior unknown.

Length 7, width 8 lines.

Obs. This species is variable in its shape, being either transversely or longitudinally oval, and at times almost circular. It is possible that the much larger shell I described in 1848 by the name of *Discina Verneuilii*, from the Wenlock limestone, may be a full-grown specimen or variety of Sowerby's species; but as there exists some uncertainty upon the subject, it is preferable to retain it provisionally as a species.

Position and Locality. *D. striata* is stated by Sowerby to have been found by Sir R. Murchison in the Upper Ludlow rocks of Delbury, Shropshire; and it occurs also in the same kind of rock at Benson Knot, Kendal, Westmoreland, if the Cambridge Museum specimens described by M'Coy really belong to the species under description. Phillips and Salter state that it occurs at Henllyn, Pencarreg, in the Builth district ('Memoirs of the Geological Survey of Great Britain,' vol. ii, p. 276).

DISCINA VERNEUILII, Dav. Pl. VI, fig. 5.

Bullet. Soc. Géol., France, 2nd ser., vol. v, p. 334, pl. iii, fig. 47, 1848.

Ovate, longer than wide; upper valve moderately convex; no defined apex; surface ornamented very similarly to what we see in *Discina striata* (type). Lower or attached valve almost flat, or very slightly convex posteriorly. The slit or foramen is longitudinally oval, and extends but a little way from near the middle of the posterior margin towards the centre of the valve. Surface ornamented as in *D. striata*. Interior unknown.

Length 15, width 13 lines.

Position and Locality. I am acquainted with but one bivalve example of this beautiful shell: it was found by the late Mr. D. Sharpe in the Wenlock limestone of Stoney Hill, near Ledbury. The original specimen was presented by Mr. Sharpe to the Geological Society.

DISCINA CRASSA, *Hall* (sp.). Pl. VI, figs. 6, 7.

- ORBICULA ? CRASSA, *Hall*. Pal. New York, vol. i, p. 290, pl. lxxix, fig. 8 *a, b*, 1847.
 — — *Murchison and Salter*. Quart. Journal Geol. Soc., vol. vii, p. 151,
 fig. 7, and pl. x, figs. 3, 4, 1851.
 DISCINA — *Salter*. Siluria, 2nd ed., p. 542, 1859.

Spec. Char. Ovate-orbicular or almost round, rather narrower posteriorly ; upper or free valve slightly convex and depressed, the incurved apex close to the posterior margin ; surface marked with numerous very fine thread-like radiating striæ, which increase in number by numerous interpolations near the margin, the whole being crossed by very fine concentric lines and wrinkles or rugæ ; lower valve not known. Two specimens measured—

Length 6, width $5\frac{1}{2}$ lines.

„ 6, „ 7 „

Obs. Prof. Hall describes his species as follows—“Ovate-orbicular, with the apex near the narrower extremity ; apex obtuse ; surface marked by strong concentric wrinkles and fine radiating striæ.” And Mr. Salter observes, in his description of the Ayrshire specimens, that they appear to be exactly the same with some others from the Hudson River group, two miles N.E. of Troy, New York.

Position and Locality. In England it occurs in the Llandeilo flags of Builth (Geological Survey) ; in the Caradoc beds near Llanfyllin ; also in the same rock at Gretton, Shropshire. In Scotland it is found in the Caradoc beds at Ardwell and Penwhapple Glen, Ayrshire.

DISCINA (TREMATIS) PUNCTATA, *Sow.* (sp.) Pl. VI, fig. 9.

- ORBICULA ? PUNCTATA, *Sow.* (*O. granulata* in the description, *O. punctata* in the explanation of plate.) Silurian System, p. 636, pl. xx, fig. 5, 1839.
 TREMATIS — *Sharpe*. Quarterly Journal of Geological Society, vol. v, p. 69, 1847.
 DISCINA, — *Salter*. Siluria, 2nd ed., pl. v, fig. 17, 1859.

Spec. Char. Nearly circular in outline, or slightly ovate ; upper or free valve moderately convex, the rounded apex being rather close to the posterior margin. External surface covered with raised, delicate, thread-like ridges, forming all over the shell a network of minute six-sided cells, the bottom of the cells being flat and margined by the slightly raised hexagonal ridge. The lower or foraminated valve is conoidal or slightly convex, with a sunk oval-shaped slit, commencing at about the middle of the

valve, and reaching to near the posterior margin; external surface ornamented as in the opposite one. Interior unknown. Two specimens measured—

Length 7, width $7\frac{1}{2}$ lines.

„ 6, „ 5 „ (Sowerby's type).

Obs. Sowerby's short description, "lenticular, punctated," and his accompanying very imperfect figure, afford no idea of the species named *Orbicula granulata* in his description and *O. punctata* in the explanation of his figure. One of these names only can be retained, and, as that of "*punctata*" is best known, it has been adopted. In 1847 Mr. D. Sharpe redescribed the same species under the designation of *Trematis punctata*:—"Ovate, depressed, surface smooth, punctations very large. Length $\frac{5}{8}$ ths, breadth $\frac{1}{2}$ inch. Found in the Caradoc sandstone at Chatwall, on the east flank of the Caradoc. The specimen described by Mr. Sowerby [an internal cast] is now in the Geological Society's collection; it is very imperfect, and does not show the principal characters of the species. Mr. Sowerby placed it in *Orbicula* with a mark of doubt." However, neither Sowerby nor Mr. Sharpe seems to have understood the character of the shell they had the intention of describing, for they mistook the pits formed by the little hexagonal network for punctures, while, as stated by Dr. Carpenter at p. 39 of my 'General Introduction,' "The shell does not depart in any essential particular from the type of *Discinidæ*, the supposed punctated surface being (as in *Porambonites*) a mere superficial conformation, and Mr. Sharpe's 'internal unpunctated layer' being a succession of laminæ, such as in *Discina*." At p. 68 of Mr. Sharpe's above-named paper he describes his genus *Trematis* as "a sub-orbicular, inequivalve Brachiopod, attached by a ligament passing through a longitudinal fissure in the posterior part of the ventral valve. Valves united by a hinge, which is supposed to resemble that of *Terebratula*, and is accompanied in the dorsal valve by three diverging internal plates. Shell regularly punctated externally, nearly fibrous, and slightly striated internally."

This description is evidently founded partly on suppositions and erroneous observations. Mr. Sharpe *supposes* only that the valves are united by a hinge resembling that of *Terebratula*; but his specimens and his figures show no evidence of such having been the case; nor does Prof. J. Hall, in his description of *Orbicula terminalis* (the type of Sharpe's genus *Trematis*), make any allusion to an articulated hinge as in *Terebratula*; and all analogies tend to make us believe that its valves were, as in *Discina*, kept in place by muscular action, and not through the medium of teeth and sockets, as in *Terebratula*. Indeed, since we are not in possession of the internal surface of the valves of any of the known species of *Trematis*, we cannot point out any differences which might entitle Mr. Sharpe's so-termed genus to be distinguished from *Discina* proper. The cell-like or net-like sculpture is not quite regular over the surface in all specimens; for at times, after a sudden interruption in the growth of the shell, the cells began again, by being smaller or larger than those which existed at the time the interruption took place. Up to the present time *D. punctata* had not been properly figured. I have therefore endeavoured, in

the accompanying illustrations, to give the external characters by means of considerably enlarged figures.

Position and Locality. Sowerby's original specimen, in the Museum of the Geological Society, is stated to have been obtained from the Caradoc beds of Chatwall, on the east flank of Caradoc. It occurs in the same rock at Cheney Longville Lane, Shropshire, and at Bowdler, near Church Stretton, in the same county. Specimens showing portions of the sculptured shell may be seen in the Museum of the Geological Survey. It is most commonly found in the condition of casts. Mr. Lightbody has obtained the shell in the Caradoc sandstone of Onny, at Marshbrook, and in several other localities. No perfect example has, however, been hitherto discovered.

DISCINA (TREMATIS) SILURIANA, *Dav.* Pl. VI, fig. 8.

Spec. Char. Orbicular, posteriorly slightly acuminate, wider than long; upper or free valve depressed or very moderately convex, most so in the proximity of its umbonal extremity, the apex being submarginal or close upon the posterior margin. External surface covered with close-set, raised, flattened, thread-like ridges, radiating from the apex and increasing in number near the margin by an additional small interpolated ridge along the centre and between each two of the original ribs. The concave interspaces left between the radiating ridges are occupied by a succession of small transversely oval cells, which are encircled, or separated from each other, by smaller transverse ridges or bars. The cells are slightly concave, but do not penetrate further than the surface of the shell. Interior unknown.

Length 7, width 8, depth 2 lines.

Obs. Of this beautifully sculptured shell I am acquainted with several upper valves; the lower or perforated valve has not been hitherto discovered. In one example, around the middle of the shell I have counted as many as one hundred principal radiating ridges, while near the margin the number had increased to 180; the interspaces between each of the principal pair of ridges was also divided into sixty or seventy consecutive oval cells, separated from each other by smaller ridges. At and close to the vertex the shell is smooth, the cells commencing by a succession of small dots, which become gradually larger and more defined as they near the middle of the valve; from that point they again become smaller and smaller as they approach the margin. One cannot, therefore, say that the radiating ridges, or rather the interspaces between them, are crossed by concentric elevated lines, because the smaller ridges separating the cells are independent, and not on the same line or level with those in the adjoining rows (fig. 8 *b*).

In the Museum of the Geological Survey, London, a very fine example of the shell under description has been labelled *Discina (Trematis) cancellata*; but after an attentive

examination and comparison of the English shell so named with the original example of the Canadian *Orbicula cancellata*, Sowerby,¹ which had been presented by Dr. J. J. Bigsby to that Museum, Mr. Etheridge and myself arrived at the conclusion that they were specifically distinct, and that a separate designation should be given to the English shell. *D. Siluriana* is comparatively broader, the apex sub-marginal, that is to say, more elevated and distinct from the margin-line of the shell, while in *D. cancellata* there exists no distinct apex, the free valve being orbicular and very slightly convex, the posterior portion forming a small, pointed, incurved beak. The sculpture is also slightly different in its details, for the Canadian shell is more regularly reticulated, on account of the concentric raised lines dividing the cells being more continuous and regular, while in *D. Siluriana* there exists no continuous concentric lines, as has been already described.

Position and Locality. In the Caradoc beds of Horderley, Salop; also at Marshbrook, in the same formation. (Mus. Pract. Geology.)

Sub-genus—ORBICULOIDEA, *d' Orb.*, 1847.

ORBICULA and DISCINA, in part, of some authors; *Schizotreta*, Kutorga;² Davidson, Monogr., vol. i, Introduction, p. 129.

Prof. Morris justly observes in his interesting 'Note on the Genus *Siphonotreta*,³ that Dr. S. Kutorga's genus *Schizotreta* is synonymous with *Orbiculoidea*, D'Orbigny, and presents

¹ Mr. Sowerby gives us the following description of his shell, *Orbicula cancellata*, G. B. Sowerby, 'Zoological Journal,' vol. ii, pl. xi, fig. 6, 1826:—"Sp. *O. cancellata*, testâ orbiculari, vertice postico, marginali; valvarum superficie lineis elevatis, confertis, radiantibus, lineis incrementi elevatis decussatis; valvæ inferioris vertice excentrali, lævi, depresso, sinu byssi parvo, brevi. The general form of this shell is orbicular and very flat, being more gibbous near the posterior extremity; the vertex of the upper valve is quite marginal and posterior; its surface is covered with close-set elevated lines, radiating from the vertex, and which are crossed by the elevated lines of growth, so that the entire surface has a finely reticulated appearance; the vertex of the lower valve is also nearly marginal, having at the *posterior edge* a rather deep cavity, in which the sinus (through which the disc of attachment passes) is placed; the surface of this valve is reticulated in the same manner as in the other, except near the umbo, where it is smooth, and the lines of growth are not elevated, but form complete rings, partly descending into the cavity above mentioned; the shell is extremely thin; it occurs in a light brownish-grey limestone, containing also remains of Terebratulæ and Coralloids. I am indebted to Dr. Bigsby for the opportunity of describing this species, which he brought from horizontal beds of limestone, resting on augitic trap, one mile north of Montreal, in Lower Canada." In the 'Geology of Canada,' "Palæozoic Fossils," vol. i, p. 52, 1862, Mr. Billings describes two more Canadian *Discinæ*, which appear to resemble *D. cancellata*, namely, *Trematis Hawaensis* and *T. Huronensis*.

² 'Ueber die Siphonotretæ, Verhandlungen der Kaiserlichen Mineralogischen Gesellschaft für das Jahr,' 1847, p. 250, St. Petersburg, 1848.

³ 'Annals and Mag. of Nat. Hist.,' 2nd ser. vol. iv, p. 315, Nov., 1849.

some, but probably only minor, characters which separate it from the ordinary *Orbiculæ* (*Discinæ*); the shell is generally more solid and calcareous; both valves are nearly equally convex, and the passage for the muscle of attachment, instead of being through a *longitudinal fissure* as in *Orbicula* (*Discina*), is considerably contracted, being confined to a small *tubular perforation* situated at the marginal end of a rather deep closed furrow. The pedunculated form assumed by the muscle of attachment must have allowed greater freedom of motion to the animal, and may be the reason for the more conical development of the lower valve in this genus, as distinguished from the compressed form of the same valve in *Orbicula*." He also adds that Dr. Kutorga was certainly mistaken when placing *Schizotreta* in his family of *Siphonotreteæ*.

I entirely coincide with Prof. Morris in the above remarks; but, as no interiors of *Orbiculoidea* have yet been discovered, it has not been possible to compare its muscular impressions with those of *Discina*. It may be desirable to maintain provisionally D'Orbigny's subgeneric designation for the forms possessing the characters above described.

O. Forbesii is the only British species we can at present with certainty refer to D'Orbigny's subgenus. In his 'Prodrome' *Discina Morrisii* is referred to the same group, but I do not think there is sufficient evidence for this.

ORBICULOIDEÆ FORBESII, *Dav.*, 1848. Pl. VII, figs. 14—18.

ORBICULA FORBESII,	<i>Dav.</i>	Bull. Soc. Géol. France, 2nd ser., vol. v, p. 334, pl. iii, fig. 45, May, 1848.
—	—	<i>Phillips and Salter.</i> Memoirs of the Geological Survey of Great Britain, vol. ii, Part I; Palæontological Appendix, p. 371, pl. xxvi, fig. 2, 1848.
ORBICULOIDEA —	<i>Dav.</i>	D'Orbigny, Prodrome de Paléontologie Stratigraphique, vol. i, p. 44, 1849.
—	—	<i>Morris.</i> Ann. and Mag. of Nat. Hist., 2nd ser., vol. iv, p. 321, pl. vii, fig. 3, 1849.
DISCINA	—	<i>Morris.</i> Catalogue, p. 134, 1854.
—	—	<i>Salter.</i> Siluria, 2nd ed., p. 250, fig. 11, 1859.

Spec. Char. Shell longitudinally oval, rather narrower posteriorly; both valves convex; the upper or free one most so, conoidal or limpet-like, being more or less elevated; the apex is subcentral, but varies in position between the centre and the posterior margin; the external surface is regularly marked with concentric ridges or lines of growth. The opposite or perforated valve has its apex also subcentral, and sometimes near the posterior margin. The small circular perforation is placed close to the marginal end of a longitudinal and rather deep sulcus, which varies in length at different ages and in different specimens. The external surface is regularly marked with narrow concentric

ridges, with wider interspaces between them, the ridges not extending over the surface of the sulcus, which is smooth or very finely striated transversely. Proportions variable; two specimens measured—

Length $13\frac{1}{2}$, width 13 lines.

„ 12, „ 10 „

Obs. It has been suggested by Prof. Morris that this shell might be the same as the *Schizotreta elliptica* of Kutorga;¹ and the same author further observed that it is probably the older form of *Patella implicata*, Sow. ('Sil. Syst.,' t. xii, fig. 14a), as well as identical with *Patella antiquissima*, Markl. ('His. Leth. Suec.,' t. xii, fig. 11). We must, however, at once dismiss the last two suppositions; for it will be seen, further on, that the so-termed *Patella implicata*, Sow., belongs to the genus *Crania*; and it is sufficient to glance at Hisinger's figure of *Patella antiquissima* to feel satisfied that it is not the shell under description, and in all probability not even a Brachiopod. Some uncertainty, it is true, has been expressed as to whether Kutorga's *Schizotreta elliptica* might not belong to the same species as my *O. Forbesii*; and, unfortunately, I was unable to procure a sight of the Russian shell on which Kutorga founded his species. But, judging from the figure, it would appear to be a much smaller shell than ours; and the apex of the free valve is much closer to the margin.² Prof. M'Coy's synonymy of his *Orbiculoidea implicata* (Sow., sp. ?) is very defective; for he considers Kutorga's *Sch. elliptica* as a synonym of Sowerby's species, which, as we have already stated, is a *Crania*. I will, therefore, retain the specific designation of "*Forbesii*" for our well-known British shell.

Some adult examples of *O. Forbesii* are almost circular, with the free valve exceedingly convex, and the apex almost central. The groove in the opposite valve is of an elongated oval shape with an inner ridge, is nearly smooth, and up to a certain age, no doubt, had a pedicle issuing from its small circular aperture; but this appears to have become cicatrized with age (?), for it cannot be observed in some very adult specimens. The first British figure of this interesting shell was published by myself in the 'Bulletin Soc. Géol. France;' and in the same year (1848) a very beautiful figure of the attached valve was published by Phillips and Salter in the 'Memoirs of the Geological Survey.'

Position and Locality. *Orbiculoidea Forbesii* has been found in the Woolhope beds and Wenlock limestone and shales. It occurs in the Wenlock limestone of Dormington Wood, Woolhope; at Winnal's Farm, Malvern; at Marloes Bay (Mus. Geol. Survey); also in the Wenlock limestone near Dudley (British Museum).

¹ 'Verhandlungen der Kaiserlichen Mineral. Gesellschaft für das Jahr,' 1847, pl. vii, fig. 6.

² *Orbicula elliptica*, Kutorga, 'Dritter Beitrag zur Palæontologie Russlands,' p. 48, pl. vii, fig. 7, 1846, Silur. Kalkstein von Pulkowa; and *Schizotreta elliptica*, Kutorga, 'Verhandlungen Kais. Min. Gesell.,' 1847. Dr. Volborth informs me (21st of Feb., 1866) that the specimen of *Schizotreta elliptica* from Pulkowa, described and figured by M. Kutorga, appears to have been lost. During the lifetime of Dr. Kutorga, he had asked for the loan of it, but it could never be found; and no specimens of the species seems to occur in Russian collections.

? ORBICULOIDEA BECKETTIANA, *Dav.* Pl. VII, fig. 19.

Spec. Char. Longitudinally oval; upper or free valve conoidal or limpet-like, and moderately elevated, the vertex being situated at about one third of the length of the valve from the posterior margin. External surface covered with numerous concentric, rounded ridges; these ridges becoming wider as they approach the middle, and again gradually smaller as they get nearer to the margin; one specimen, showing as many as fifty of these rounded ridges, measured—

Length 5 inches 5 lines, width 4 inches 8 lines. Attached valve unknown.

Obs. It is with considerable uncertainty that I refer this fragment to the Brachiopoda at all; and Mr. Salter, who has arranged it for many years as possibly a *Discina*, in the Museum of Practical Geology, shares my doubts. It appears, however, to both of us, to be unlike anything else; and, as two incomplete specimens only, in the condition of casts, were found by Mr. H. Beckett in the Wenlock limestone of the Wren's Nest, Dudley, we must wait for further information. If the discovery of more complete examples should confirm our present supposition, this is by far the largest species of the genus, and, indeed, almost the largest Brachiopod, hitherto discovered.

Genus—SIPHONOTRETA, *De Verneuil*, 1845.

Ref. De Verneuil, 'Russia and Ural Mountains,' vol. ii, 1845. See also Kutorga, 'Ueber die Siphonotretæ, Verhandlungen der Kaiserlichen Mineralogischen Gesellschaft' für das Jahr, 1847. Davidson, 'British Fossil Brachiopoda,' vol. i, Introduction, p. 131.

In the Silurian rocks of Great Britain two species have been discovered, namely, *Siphonotreta Anglica* and *S. micula*.

SIPHONOTRETA ANGLICA, *Morris*, 1849. Pl. VIII, fig. 1.

SIPHONOTRETA ANGLICA, *Morris*. Annals of Nat. Hist., 2nd ser., vol. iv, p. 320, pl. vii, fig. 1, *a—e*, 1849.

— — *M'Coy*. British Pal. Foss., p. 188, 1852.

— — *Salter*. Siluria, 2nd edit., p. 212, fig. 3, 1859.

Spec. Char. Shell ovate longitudinally; dorsal valve very slightly convex or depressed, ventral valve most convex and deepest about the middle; beak produced, with a small oval perforation or foramen at its extremity. The surface of each valve is marked

with close concentric striæ, as well as with minute punctures, and studded also with slender tubular spines, which are very wide at their base.

Length 6, width 5 lines. Interior unknown.

Obs. It is to Prof. Morris that we are indebted for the first description and figures of this interesting Brachiopod; and his article upon the subject is full of interest, for, besides describing the first-known British species of the genus, he gives us a translation of a portion of Dr. Kutorga's valuable paper on the genus *Siphonotreta*. Speaking of *S. Anglica*, Prof. Morris mentions that the surface is "minutely but concentrically reticulated; reticulation regular, with quadrangular areolæ, and covered with many slender, linear, tubular spines or their bases, somewhat quincuncially arranged; spines smooth, dilated at their base, a little above which they remain of uniform size throughout, or very slightly tapering, and are regularly and transversely sulcated or contracted, giving the spines a beaded or jointed appearance; the general form of the shell and quincuncial arrangement of the spines resemble *S. aculeata*, Kutorga; but as that author does not figure or allude to any reticulated structure or the moniliform spines, this is considered to be distinct." Prof. Morris was acquainted with a single, much compressed dorsal valve found by Mr. John Gray in Wenlock shale near Dudley; but subsequently Prof. M'Coy described the ventral valve from specimens in the shale nodules of Sunny Banks, Coniston, where, however, the shell is not so perfectly preserved as near Dudley. In his description, Prof. M'Coy states that the "imperforate valve is suborbicular, depressed; the perforate valve ovate, very convex in the middle, most so about one third from the beak; beak produced, with a distinct perforation; surface of both valves with minute, close, imbricating, concentric striæ, about fifteen in the space of one line, reticulated by minute close punctures, less than their diameter apart, their diameter equalling the width of the imbricating lines from each other."

SIPHONOTRETA MICULA, *M'Coy*, 1851. Pl. VIII, figs. 2—6.

SIPHONOTRETA MICULA, *M'Coy*. Ann. Nat. Hist., 2nd ser., vol. viii, p. 389, 1851; and

British Pal. Foss., p. 188, pl. i, n, fig. 3, 1852.

— — *Salter*. Siluria, 2nd ed., p. 212, fig. 3, 1859.

— — *Harkness*. Geol. Mag., vol. ii, p. 431, 1865.

Spec. Char. Shell minute, longitudinally ovate, as broad as long, posteriorly slightly acuminate, the front and side margins broadly rounded; valves very slightly convex, the ventral one most so, with a small circular foramen at its extremity. Surface marked with concentric laminar striæ, and with very small punctations, having raised borders; when perfect, there are numerous delicate short spines.

A large specimen measured 2 lines in length by the same in breadth.

Obs. Prof. M'Coy, the first describer of this little species, states that it varies from nearly orbicular to ovato-pentagonal in outline. "In some specimens, particularly those

from Wellfield, the depressions left by the spines of the surface are very obvious and rather crowded, producing a puckered irregularity of the surface, which is not to be seen in most of the specimens from Pen Cerrig; the concentric lineation is also more distant in the former, between which the reticular punctation is so excessively minute that it can only be traced with a powerful lens, in favorable lights, on the best preserved portions of the shell, differing, therefore, very much from the most nearly allied fossil, the so-called *Terebratula hamifera*, Barrande. In nearly all the specimens the distinct and rather large circular opening at the apex of the beak is easily seen, and in many specimens an irregular fissure, apparently produced by crushing, extends a variable distance towards the front margin, either in the medial line or more or less to one side or the other. The few rather large concentric waves or interruptions of growth are only seen in some specimens.

"This species seems to agree in everything with the little *Terebratula hamifera*, Barrande ('Haidinger's Naturwissenschaftliche Abhandlungen,' vol. i, p. 418, t. 20, fig. 9); but has the reticular punctation infinitely more minute than he describes that of his species to be (half a millimètre long, or four in a square millimètre)."

M. Barrande gives the geological place of his species in Bohemia as the highest beds, or the quartzite stage, D, of the Lower Silurian. The schists in which it occurs in such profusion in Britain are, Mr. Salter says, much lower. Its gregarious habits are curiously shown by the circumstance of a fragment of shale, from Pen Cerrig, four or five inches long and wide, having afforded upwards of a hundred specimens now in the Cambridge Collection; and another mass, not much larger, from Wellfield, having yielded upwards of seventy (M'Coy). I am very doubtful as to the correctness of Prof. M'Coy's comparison of his little shell with the *T. hamifera*, Barrande.

Position and Locality. It abounds in the Llandeilo flags at Wye Ford, Builth, Radnorshire; also in the same formation at Conway Castle. In Scotland it was found by Prof. Harkness in the Graptolite-shales, at Lambfoot, Glenkiln Burn, Kirkeniecheal, about nine miles east of Dumfries; also at Garpool Burn, near Moffat, where it occurs in a very thin bed or layer, not more than two inches thick. A small specimen was also found by Mr. R. Gray at Balcleachie, near Girvan, in Ayrshire. In Ireland it occurs in the Lower Silurian black slates of Bellewstown, county of Meath (Irish Survey Coll.).

FAMILY—CRANIADÆ.

Genus—CRANIA, *Retzius*, 1781.

Ref. Davidson, 'British Foss. Brach.,' vol. i, Introduction, p. 122; and vol. ii, 'British Carb. Brach.,' p. 192.

CRANIA DIVARICATA, *M'Coy*, sp. Pl. VIII, figs. 7—12.

CRANIA ANTIQUISSIMA (?), *M'Coy*. Not of Eichwald. Synopsis of the Silurian Fossils of Ireland, p. 25, 1846.

PSEUDO-CRANIA DIVARICATA, *M'Coy*. Ann. Nat. Hist., 2nd ser., vol. viii, p. 388, 1851; and Brit. Pal. Foss., p. 187, pl. i, n, figs. 1, 2, 1852.

CRANIA — *Dav.* Monogr., vol. i, Introd. p. 122, pl. ix, figs. 246, 247, 1853.

— CATENULATA (*Salter*, MS.), *Baily*. Data and Descriptions to accompany Quarter-sheet 35 N.E. of the Map of the Geolog. Survey of Ireland, p. 9, fig. 3, 1858.

— DIVARICATA, *Salter*. Siluria, 2nd ed., p. 212, fig. 2, 1859.

Spec. Char.—Shell unattached; usually longitudinally oblong-oval, sometimes slightly transversely so, or as wide as long, rather narrowed posteriorly, widest anteriorly. Posterior margin slightly indented. Valves flattened or very gently convex, and ornamented with numerous narrow, sharp, slightly prominent, radiating ribs or raised striæ, increasing in number by the interpolation between the principal ribs of additional riblets, which commencing at variable distances from the posterior margin, extend to the front; a few concentric lines of growth traverse the surface of the valves. Three examples measured—

Length 6, width 7 lines

„ 9½, „ 11 „

„ 11, „ 11½ „

Obs.—The interior of the *dorsal* valve presents a wide broad margin indented posteriorly (fig. 11, m). The divaricator oval scars (r), which lie close to the inner edge of the posterior portion of the flattened margin, are not very strongly indented, and present but small elevations on the cast; towards the middle of the shell, or rather nearer to the posterior than anterior margin, may be seen two obliquely placed, ovate, muscular impressions, slightly concave in the shell (projecting in the cast) and separated from each other near their base by a space about equalling one of their width. These impressions are surrounded by a narrow ridge, and are (as supposed by Mr. Hancock) referable to the occlusor

or adductor muscle. A narrow longitudinal ridge in the shell (depression on the cast) commences between the last-described impressions and extends to some distance in the direction of the anterior portion of the shell, and on either side of its extremity may be seen a small oval scar, which has been supposed attributable to the brachial muscle. The internal concave space beyond the visceral portion of the shell, and within the flattened margin or anterior half of the valve, is covered with narrow radiating ridges, bifurcating at their extremities, and with broader interspaces between them. The interior of the ventral valve differs from the dorsal one by having its divaricator scars much narrower, and its ocluser impressions closer at the anterior extremity, and leaving only a very small space between them for the two little scars which Mr. Hancock thinks might belong to the anterior extremity of the dorsal adjustor. The ocluser or adductor muscular impressions in this valve are slightly concave, but projecting in the cast, and the remaining concave space is, as in the opposite valve, covered with slightly raised ridges, with wide, slightly concave interspaces.

At page 25 of his 'Synopsis of the Silurian Fossils of Ireland,' published in 1846, Prof. M'Coy refers, with uncertainty, the shell under description to the *Crania antiquissima* of Eichwald; and subsequently, at p. 187 of his 'British Palæozoic Fossils,' he observes that "in size and general character this shell agrees with *Pseudo-crania antiquissima* (Eichw., sp.) as given by M. de Verneuil ('Geol. of Russia,' vol. ii, pl. i, fig. 12), but is easily distinguishable externally by the beak being close to the posterior margin and by the remarkably divaricating sculpture of the valves, and internally by several minor points of detail obvious by comparing the figures." I quite coincide with the distinguished Irish palæontologist, the Irish and Russian forms being specifically distinct; the last is smooth externally, while the former is striated or costate; but not feeling satisfied with M. de Verneuil's figure of the interior of *C. antiquissima*, as it showed no divaricator impressions in the shell, I obtained from my friend Dr. Volborth, of St. Petersburg, two well-preserved examples of the Russian species, which showed in the interior of the ventral valve two distinctly marked narrow divaricator scars, very similar in shape and position to those seen in our own British species. The principal internal difference consists in the ocluser or adductor scars being very prominent in Eichwald's species; while they are, on the contrary, slightly concave in the British shell. Both species, however, may be placed in the same section of the genus *Crania* (unattached species).

Prof. M'Coy figures the exterior and internal casts of the ventral valve only, but in our plate will be found the interior of both valves, enlarged so as to show all their interior characters.

Mr. Baily's figure of the internal cast of *C. catenulata* cannot be quite correct, for the divaricator impressions, besides being out of shape, are too large in proportion to the ocluser or adductor marks.

Position and locality. Mr. Salter first collected this shell, and described it as *C. catenulata*, at the Meeting of the British Association at Cambridge, 1846. It is

common in the schists of the Caradoc or Bala limestone at several places near Bala, Merionethshire; also at Pont-y-Glyn Diffwys, West of Corwen, in the same county; and it occurs in the Llandeilo grits of Tan-y-Craig, Builth; also at Bala Lake.

Mr. Prosser sent me an internal cast (the one I figure) of the ventral valve which he had found in the shales of the Bala limestone near Llanfyllin. It occurs also in Denbighshire, south-east of Cerrig-y-Druidion. In Ireland it is exceedingly abundant, always in the condition of internal casts and impressions, in the Caradoc slates of the Chair of Kildare,¹ Cahiranearla. It is also found at Grangegeeth, Kildare; and at Frankfort and Newtown Head, Waterford. From these localities fine series of specimens have been obtained for the Museums of the Geological Survey in London and Dublin.

CRANIA IMPLICATA, *Sow.* sp. Pl. VIII, figs. 13—18.

PATELLA IMPLICATA, *Sow.* Silurian System, pl. xii, fig. 14 *a*, 1839.

ORBICULOIDEA IMPLICATA, *M'Coy.* British Pal. Foss., p. 189, 1852.

CRANIA² IMPLICATA, *Salter.* Siluria, 2nd ed., pl. xx, fig. 4, 1859.

Spec. Char.—Shell very small, longitudinally oval, free, or unattached; slightly inequivalve; ventral valve gently convex, highest part or vertex sub-central, being closer to the posterior than to the anterior edge, and marked with concentric, slightly raised, or step-like bands of growth. Dorsal valve rather deeper than the opposite one, limpet-like, the pointed apex being likewise nearer to the posterior than to the anterior margin; surface marked with concentric lines of growth, less prominent than those on the other valve. The interior of the ventral valve shows a broad, flat, concentrically striated margin, with two small, narrow, oval-shaped divaricator muscular scars, obliquely placed, and in close contiguity to the posterior portion of the flattened margin, but separated from each other in the middle by a space about equalling half the length of one of the impressions; towards the middle of the concave valve two ovate, slightly depressed occlusor or adductor muscular impressions are visible, and separated from each other by a small, tongue-shaped, slightly raised, flattened projection, these impressions being likewise somewhat elevated in front. The interior of the dorsal valve is at present unknown.

Length about 2, width $2\frac{1}{2}$ lines.

Obs. This little shell appears to have puzzled more than one palæontologist. In 1839 Sowerby described it as follows:

“*Patella? implicata*, fig. 14 *a*. Oval, depressed, surface composed of concentric laminæ;

¹ An interesting account of the Lower Silurian rocks of the Chair of Kildare, by Mr. G. V. Du Noyer, will be found in the description accompanying Quarter-sheet 35 N.E. of the Map of the Geological Survey of Ireland, 1858.

² “*Discina*” in the Appendix, p. 542.

longest diameter 2 lines. We have only seen the upper surface of this small shell, and therefore assign its generic name with doubt. It bears some resemblance to *P. antiquissima* ('His. Pet. Succ.,' p. 45, t. xii, fig. 10), and may represent that fossil in its young state. We have several individuals, all of one size, on the same mass of stone with *Sp. octoplicatus* (?). Loc. Abberley."

Subsequently, in 1852, Prof. M'Coy confounds it with the *Schizotreta elliptica*, Kutorga, which he supposes to be a synonym of Sowerby's shell, and consequently places *P. implicata* in D'Orbigny's genus *Orbiculoidea*. Morris, in 1854 ('Catalogue,' p. 134), commits a similar mistake, for he places this shell with *DISCINA*. In the second edition of 'Siluria' it is properly considered by Salter as a *CRANIA*; and any one who has seen bivalve examples of the species would at once perceive that it is not a *Discina*, and that its interior is that of a *Crania*.

In a paper "On the Silurian and Devonian Rocks of Nova Scotia," by Dr. J. W. Dawson, and published by the Natural History Society of Montreal, Prof. J. Hall figures and describes a small shell, under the name of *Crania Acadiensis*. Dr. Dawson has sent me an internal cast of this Nova-Scotian fossil, and I find that it certainly belongs to the genus *Crania*; and, indeed, so closely does it resemble our English shell, that I feel inclined to add its name to our list of synonyms.¹ Prof. Hall states also, at p. 250 of the 2nd vol. of his 'Palæontology of New York,' "that his own *Orbicula? squamiformis*, op. cit., pl. liii, fig. 4, and 'Geol. Report,' 1843, p. 108, fig. 1, is probably identical with *Patella? implicata* of Murchison's 'Silurian System,' p. 62, pl. xii, fig. 14 a. The American shell occurs in the "Niagara Shale," and its thin calcareous layers, at Lockport, and at Rochester and Sweden in Monroe County. In size and shape it agrees with our *C. implicata*; is said to be very fragile, and is marked by strong concentric lamellæ; it is, therefore, probable that when the interior of this shell is seen it may have to be included amongst the synonyms of Sowerby's species.

Prof. J. Hall further informs me by letter, that, in 1859, he proposed a genus, "*Pholidops*," for such shells as *Crania (Patella) implicata*, Sow.; but I am not quite satisfied that it should include the shell under description.²

Position and Locality. Of this shell I have seen specimens from the Upper Llandovery beds of Mandinam, Llandovery; the Wenlock shales of Ledbury; Wenlock limestone of Rock Farm, May Hill; from Wenlock shales near Walsall, and from Upper Ludlow rock at Bradnor Hill, Presteign, north-west of Hereford; in the last locality it occurs by millions, in the condition of minute internal casts. From Ireland I have seen a specimen

¹ The figure of the Nova-Scotian shell is reproduced in Dr. Dawson's 'Acadian Geology,' p. 68, 1855.

² Genus *Pholidops*, Hall. 'Pal. New York,' vol. iii, p. 489. "Shell small, patelliform; apex sub-central, excentric, or terminal. Surface marked by concentric lines of growth, which are more expanded on the posterior side. Interior a shallow oval cavity, with bilobed muscular impressions, the margins flattened or slightly deflected and entire." See also 'Thirteenth Annual Report of the State Cabinet,' p. 92, 1860. Types, *P. squamiformis*, *P. Hamiltoniæ*.

or two from Wenlock beds at Ferriter's Cove, County Kerry. A small specimen, probably referable to this species, was found by Mr. Brown in the Ludlow beds of the Pentland Hills.

CRANIA SILURIANA, *Dav.* Pl. VIII, figs. 19, 20.

Spec. Char. Shell marginally subquadrate or nearly circular, posterior margin nearly straight. Ventral valve adhering to marine bodies by its entire surface; dorsal valve slightly conical or limpet-like; vertex subcentral, and closer to the posterior than to the anterior margin. The interior of the attached valve shows the muscular scars peculiar to the genus *Crania*. Exterior surface rugose, or covered with more or less strongly marked concentric lines.

Length 4, breadth 4 lines.

Obs. Of this species I am acquainted with three individuals, which adhere to a specimen of *Leptaena Waltoni*, from the Wenlock shales of Falfield.

It is, however, exceedingly difficult to make a correct specific determination of these imperfectly preserved specimens; for their external shape much resembles that of several forms of attached *Cranieæ*.

CRANIA? GRAYII, *Dav.* Pl. VIII, figs. 22—24.

Spec. Char. Shell small, circular, or slightly longer than wide; upper valve limpet-like, the apex being situated nearer to the posterior than the anterior margin; surface ornamented with a variable number of narrow costæ radiating from the vertex, and increasing in number by the interpolation of one or two riblets between each two of the ribs; the former originating at variable distances from the vertex, and extending to the margin.

A large specimen measured 4 lines in length by about the same in width.

Obs. Of this little shell I am acquainted with some nine examples. Six adhere to a specimen of *Spirifera plicatella*, var. *radiata*, found by Mr. John Gray in the Wenlock limestone near Walsall, and now in the British Museum. Three other specimens were picked up by Mr. L. P. Capewell in the Wenlock limestone near Dudley. Not having seen the interior of the adhering valve, the description of this species must necessarily be incomplete. It bears some resemblance to certain Jurassic and Cretaceous species of *Crania*, to which genus it is therefore provisionally referred.

In addition to the species of *Crania* above enumerated, another fossil was formerly described by myself under the designation of *Crania Sedgwickii* (Lewis, MS.), in the

'Bulletin de la Société Géologique de France,' second series, vol. v, p. 334, pl. iii, fig. 48, 1848; but I would not again describe it as a *Crania*, as it seems to differ in several important particulars from all the species of that genus with which we are acquainted. In all probability it is not a Brachiopod at all. I have, however, carefully figured the original example now in the Museum of the Geological Survey of London (Pl. VIII, fig. 25), with the hope that by so doing the true nature of this obscure fossil may be hereafter determined. Prof. M'Coy has referred it to his own more than doubtful genus *Spondylolobus*, to which it bears no affinity.

The so-termed *C. Sedgwickii* is longitudinally oval and almost flat, with two rounded concentric ridges in the proximity of the margin, while small granulations are observable here and there over its surface. The inner surface of the fossil is slightly concave about the middle, with two raised rounded ridges corresponding to those on the external surface. At a little distance inwards, or from what we might describe as the posterior margin, rise two irregular conical projections, which are almost contiguous at their base. It measures six lines in length by five and a half in width, and was found by Mr. Lewis in the Wenlock limestone or shale of the Rushall Canal, near Walsall.

FAMILY—TEREBRATULIDÆ.

No species referable to this important family has with certainty been hitherto discovered in our British Silurian rocks. One small shell, it is true, has been described in the 'Silurian System' under the designation of *Terebratula læviuscula*, and requoted at p. 545 of 'Siluria' as a *Terebratula* with a point of interrogation; but, as will be seen in the sequel, I believe I have satisfactorily determined, after a careful examination of the original specimen preserved in the Museum of the Geological Society, that the fossil in question cannot be classed amongst the *Terebratulæ*, as the shell-structure of the so-termed *T. læviuscula* is fibrous, and not punctured; and it, moreover, agrees in shape and character of beak with *Athyris* or *Meristella nitida*, of which it is evidently a young shell.

FAMILY—SPIRIFERIDÆ.

The characters of this extensive family having been already described at some length in our General Introduction, and often subsequently adverted to in the Jurassic, Permian, Carboniferous, and Devonian Monographs, it will not be necessary to again enlarge upon the subject. In our Silurian rocks Spirifers were specifically very few in number, and almost entirely confined to the Upper Silurian period.

Genus—SPIRIFER, *Sowerby*, 1815. SPIRIFERA, *Phillips*.

SPIRIFERA PLICATELLA, *Linn.*, sp. Pl. IX, figs. 9—12.

ANOMIA PLICATELLA, *Linnaeus*. Systema Naturæ, 12th ed., p. 1154, 1767.

DELTHYRIS CYRTÆNA, *Dalman*. Kongl. Vetenskaps Handlingar. for 1827, p. 120, tab. iii, fig. 3 (Stockholm, 1828).

— — *Hisinger*. Lethæa Suecica, p. 73, pl. xxi, fig. 4, 1837.

SPIRIFER INTERLINEATUS, *J. de C. Sowerby*. Silurian System, pl. xii, fig. 6, 1839.

— — *Dav.* Bull. Soc. Géol. de France, 2nd ser., vol. v, p. 324, 1848.

— PLICATELLUS, var. INTERLINEATUS, *Salter*. Memoirs of the Geological Survey, vol. ii, p. 381, 1848.

SPIRIFERA CYRTÆNA, *M'Coy*. British Pal. Foss., p. 193, 1852.

ANOMIA PLICATELLA, *Hanley*. Ipsa Linnæi Conchylia, p. 127, 1855.

SPIRIFER CYRTÆNA, *Schmidt*. Silurische Formation von Ehstland; Archiv für die Naturkunde Liv.-Ehst-und Kurlands, vol. ii, p. 211, 1858.

— PLICATELLUS, var. INTERLINEATUS, *Salter*. Siluria, pl. xxi, fig. 1, 1859.

SPIRIFERA PLICATELLA, var. INTERLINEATA, *Lindström*. Bidrag till kannedomen om Gotlands Brachiopoder (Proceedings of the Royal Acad. of Sciences of Stockholm), p. 358, 1860.

Spec. Char. Rhomboidal, longer than broad; valves gibbous, the ventral one being considerably arched; beaks approximate; hinge-line shorter than the width of the shell, the cardinal or lateral angles being rounded. Ventral valve most convex, with a deep longitudinal sinus extending from the extremity of the beak to the front; beak incurved, area triangular, fissure partly arched over by a convex pseudo-deltidium. Dorsal valve gibbous, with a more or less elevated mesial fold, flattened or depressed along the middle; lateral portions of the valves more or less deeply divided into a greater or smaller number of large rounded ribs, while the entire surface of the shell is covered with numerous close, fine, subequal costæ, and which are crossed by still finer concentric, thread-like, elevated lines. Two specimens measured—

Length 14, width 15, depth 12 lines.

„ 13 „ 16 „ 12 „

Obs. The determination of this species and of some of its varieties or variations in shape has been attended with some difficulty. First of all, the name the shell should retain has led to some difference of opinion. Mr. Salter was the first to refer to the Linnean Cabinet for these Silurian Brachiopods, and there found specimens agreeing with the British fossil; and Mr. S. Hanley agrees with him: but the reference “ANOMIA angulis lateralibus dilatatis dentibus alternis” in the ‘Musæum Tessinianum,’

p. 90, pl. v, fig. 7, quoted by Salter with doubt at p. 381 of the 'Memoirs of the Geological Survey,' vol. ii (1848), must be, with his own consent, given up. That figure (see our Pl. X, fig. 12, A, B) is, in the twelfth edition of the 'Systema Naturæ,' named by Linnæus *Anomia crispa*. Some difficulty may yet remain in the way of our being perfectly certain as to what Linnæus intended as the typical form of his *Anomia plicatella*, for his short description—"longitudinally striated along with the ribs, lateral angles expanded," is unaccompanied by a figure. In the Linnean Cabinet may, however, be seen two specimens marked by Linnæus *A. plicatella*, one of which exactly agrees with the definition of the species subsequently termed *Delthyris cyrtæna* by Dalman, and *Spirifer interlineatus* by Sowerby, and which we must consequently regard as the typical shape of the Linnean species. At p. 194 of his 'Brit. Pal. Fossils,' Prof. M'Coy states, while describing *Sp. cyrtæna*, "This species seems to me totally distinct (when typical forms are considered) from the *Spirifer radiatus* of Sowerby, by its very strongly costated valves; and for the same reason it agrees perfectly with Dalman's *Delthyris cyrtæna*, which has usually been referred to the *Sp. radiatus* of Sow., although it is his *Sp. interlineatus* which presents the mixed costated and lineated character of Dalman's species." But Prof. M'Coy seems not to have been aware of Linnæus's prior name, and of the original specimens preserved in the Linnean cabinet, or he would probably have adopted the designation *plicatella*, placing *Sp. cyrtæna* and *Sp. interlineata* as synonyms. Messrs. Salter and Lindström seem to have forgotten the characters of the Linnean type when they propose that *Spirifer radiatus*, Sow., should be considered the type as well as a synonym of the true *An. plicatella*;¹ but they appear to me correct in deciding that *Spirifera plicatella*, *Sp. interlineata*, *Spirifer radiatus*, and *Sp. globosus* are all varieties of a single species;²

¹ At p. 127 of Hanley's 'Ipsa Linnæi Conchylia' (1855) we find the following observations, which we reproduce, that the reader may be in possession of all the facts in connection with the identification of this important species:

"The *Spirifer* delineated in our plate (4, fig. 2) is preserved in the box thus marked '*Anomia plicatella*' in the Linnean Cabinet, and perfectly agrees with the definition of the species. Mr. Salter recognised it as *Spirifer plicatellus*, var. *interlineatus*, and Mr. Davidson as the *Delthyris cyrtæna* of Dalman, which he regards as identical with the *interlineatus* of Sowerby. Besides the shell figured, there is also, in the same drawer of the Linnean collection, a specimen of *Spirifer interlineatus* (Sowerby, 'Sil. Syst.,' p. 6, fig. 6), which has fine longitudinal striæ covering rounded ribs, though in other respects a very different species from that figured. This throws a slight doubt upon the shell to be chosen for Linnæus's *A. plicatella*; but the expression '*Striæ in plicarum cavitatibus*' is so exactly applicable to the shell figured, which is smooth at the top of the ribs, while in the *interlineatus* the ribs are entirely covered with striæ, that we must adopt the former for the veritable species. I am not certain it has ever been delineated, unless Dalman's *Delthyris cyrtæna*, found in the Silurian rocks of Gothland, should be identical with it. The *Terebratula plicatella* of Dalman belongs to another genus, as does the *T. plicatella* of the 'Mineral Conchology.' (Sharpe MSS.)"

² At p. 265 of the 2nd vol. of Prof. J. Hall's 'Palæontology of New York,' 1852, we find the following interesting observations:

"M. de Verneuil cites ("Note sur le Parallelisme des Dépôts Paléozoïques de l'Amérique Septentrionale

I must again differ with my friend Mr. Salter when he proposes to include *Cyrtia exporrecta*, Wahlemborg, and *C. trapezoidalis*, Dalman, amongst the varieties of *Sp. plicatella*. When describing these last-named shells my reasons for dissenting from this view will be given.

Spirifer viator, Barrande ("Silurische Brachiopoden aus Böhmen," pl. xv, fig. 3, 1848; 'Naturwissenschaftliche Abhandlungen,' Bd. ii, p. 153).—Judging from the description, figure, and specimens, sent by M. Barrande to M. de Verneuil under that designation, it appears to us probable that *Spirifer viator* will require to be added to the synonyma of *Spirifera plicatella*, Linn.

Position and Locality. *Sp. plicatella* occurs especially plentiful in the Wenlock shales in the neighbourhood of Dudley and Walsall, Staffordshire; in the Aymestry limestone of Aymestry; and the Wenlock limestone of May Hill, of Woolhope, Ledbury, Herefordshire, Benthall Edge, &c. Phillips and Salter mention the following localities ('Mem. Geol. Survey,' vol. ii, p. 293):—Winning's Farm (Malvern district); Hole Farm, Lower Ludlow (Abberley district); Checkley Common, Wenlock Shale (Woolhope district); Craig-y-Garcyd (Usk district); Nelson's Tower Wood, Myddelton Series (Llandeilo avec ceux de l'Europe," 'Bulletin de la Soc. Géol. de France,' 2nd series, vol. iv, 1847) the *Sp. cyrtæna* of Dalman as occurring at Lockport with *Sp. Niagarensis*, and occupying the same position in Europe. A careful comparison of our specimens of *Sp. cyrtæna* from Gothland and specimens of *Sp. radiatus* of Sowerby from Dudley has convinced me that there is but a single species, and our specimens show, in a still greater degree, the variable character mentioned by Dalman. In the Swedish specimens the margin is usually plicated, the rounded plications sometimes extending half way to the beak, while in others they are only visible in the undulating outline, and sometimes are quite free from such characters. This plication of the margin appears not to be infrequent in the Dudley specimens, judging from those I have seen, and we may therefore regard the specimens from those localities as identical. In all the American specimens I have seen there is no evidence of this plication of the margin or surface, though in other respects they are almost identical with the specimens from Dudley, and it is not easy to point out any important characters by which they may be separated from the Swedish specimens. In well-preserved specimens from Gothland the striæ are sharp, or round and prominent, and crossed by conspicuous, elevated, concentric striæ, which towards the margin are undulated upon the elevations and depressions of the plications. All the New York specimens I have seen are destitute of the concentric striæ, and the longitudinal striæ are often flattened. This character, however, may arise from abrasion or partial exfoliation; and in the shale, the presence of iron-pyrites, producing solution of the surface by sulphuric acid, is a probable cause of the absence of the more minute surface-markings. It is not a little interesting to the palæontologist and zoologist to consider the fact that, while we have no evidence of a plicated surface in this species from New York (and probably all American) strata, we yet have another species of similar form, and a similarly striated surface, which is distinctly plicated from beak to base, and never deviates even in the youngest specimens seen. This species (*Sp. Niagarensis*) appears to be unknown in Europe, where the other species is common. We cannot avoid the thought that the manifestation of a peculiar feature in the *Sp. radiatus* of Europe was more strongly developed in a distinct but allied form in the western ocean, and which now appears as a characteristic species of the Niagara period.

I may here observe, that in America occurs *Spirifera plicatella*, var. *radiata*, Sow.; and, according to Prof. Hall, not the true type of Linnæus's *Sp. plicatella*, which agrees with *Sp. cyrtæna* of Gothland, and is also common in Britain.

district). Linnæus's and Dalman's specimens were obtained from the Island of Gothland ; and Herr Lindström states that it occurs in Mid-Gotland, at Klinteberg ; Linde and Sandarfve Kullar ; Løjsta ; Stora och Lilla Carlsö ; Habblingbo, and Slite.

SPIRIFERA PLICATELLA, var. RADIATA, *Sow.* Pl. IX, figs. 1—6.

DELTHYRIS LINEATUS (text), *radiatus* (Index), *Sowerby.* Min. Con., vol. v, p. 493, figs. 1, 2, May, 1825. (Not *Anomites lineatus* of Martin.)

SPIRIFER RADIATUS, *J. de C. Sow.* Silurian System, pl. xii, fig. 6, 1839.

— — *M'Coy.* A Synopsis of the Silurian Fossils of Ireland, p. 37, 1846.

— CYRTÆNA, *Dav.* Bull. Soc. Géol. de France, 2nd series, vol. v, p. 324, 1848.

— PLICATELLUS, *Salter.* Memoirs of the Geol. Survey of Great Britain, vol. ii, p. 382, 1848.

— RADIATUS, *J. Hall.* Pal. of New York, p. 66, pl. xxii, fig. 3 ; and p. 265, pl. liv, fig. 6, 1852.

— PLICATELLUS, var. RADIATUS, *Salter.* Siluria, pl. ix, fig. 25 ; and pl. xxi, fig. 7, 1859.

SPIRIFERA PLICATELLA, *Lindström.* Proceedings of the Royal Acad. of Sciences of Stockholm, p. 358, 1860.

Characters. More or less subtrigonal or rhomboidal, wider than long ; valves moderately convex, beaks more or less approximate ; hinge-line straight, usually rather less than the width of the shell, wings or cardinal extremities more or less expanded, or by an outward curve meeting the hinge-line. Ventral valve rather deeper than the opposite one, with a rounded, more or less deepened mesial sinus, extending from the extremity of the beak to the front ; beak incurved, area triangular, variable in breadth, fissure partly covered by a convex pseudo-deltidium. Dorsal valve convex, with a wide, moderately elevated, flattened mesial fold, sometimes depressed along the middle. Surface of valves generally evenly convex, or at times longitudinally divided by a few undulations, while the entire surface is covered with numerous fine, raised costæ, and here and there a smaller interpolated rib ; between each pair of costæ the interspace is concave and of smaller breadth, the whole surface being likewise closely crossed with fine, thread-like, raised, concentric lines. Two specimens measured—

Length 15, width 24, depth 11 lines.

„ 13, „ 16, *Sowerby's* type.

Obs. I greatly doubt Baron Von Buch being correct when he refers the species under description to *Terebratulites striatissimus* of Schlotheim. The last-named shell was briefly described in the 'Petrefactenkunde,' p. 252, 1820, with a reference for figure to the 'Taschenbuch für die gesammte Mineralogie,' Tafel ii, fig. 7, 1813. The locality

given by Schlotheim, in 1820, is the Chapel of Pancratius, near Prague. The figure represents an undeterminable fragment of a striated *Spirifer*, from which no certain identification can be arrived at; but I have no doubt that the Baron, at p. 47 of his 'Ueber Delthyris, oder Spirifer und Orthis,' 1837, imagines our Silurian shell from "Dudley Castle" to be the *Terebratulites striatissimus* of Schlotheim. At page 38 of the same work he considers *Delthyris cyrtæna*, Dal., from Gothland, to be a synonym of *Spirifer pinguis*, Sowerby, although no two species could be more dissimilar; and, in addition, they belong to two distinct periods.

One thing, however, may be inferred, namely, that Von Buch considered *Sp. cyrtæna*, Dal., and *Sp. radiatus*, Sow., to be two distinct species, although he adopted for both of them erroneous denominations.

The external sculpture, when well preserved, is extremely beautiful, and consists of radiating ribs (five in the width of a line in the middle of an average-sized specimen), not always quite regular in their respective widths, but usually leaving an interspace between each two of about the width of one of the ribs, and at times towards the margin there are smaller ribs interpolated; these ribs are regularly crossed by equidistant, concentric, projecting ridges, which give to the shell surface a beautifully imbricated appearance.

Position and Locality. *Spirifera plicatella*, var. *radiata*, is a very common fossil in the Wenlock limestone at Dudley.

Phillips and Salter, at p. 292, vol. ii, of the 'Memoirs' of the Geological Survey of Great Britain, name the following localities:—Brock Hill Section (Lower Ludlow); East of Ledbury (Wenlock limestone); under Worcester Beacon (Woolhope limestone), and near Winning's Farm (Caradoc¹ sandstone), all in Malvern district; Hole Farm, Lower Ludlow, and Callow Farm, Abberley district; North of Canwood, Wenlock limestone; East of Canwood, Dormington Wood; Lindels' Green; Wootton Farm, Checkley Common, in the Woolhope district; and at west of Rock Farm, Wenlock limestone; May Hill: Huntley Hill, in the May Hill district. Mr. Salter mentions its presence in the Lower Llandovery rocks of the Quaker's Burial ground, near Welchpool, the only locality known in rocks below the Upper Silurian.

In Sweden Herr Lindström found the shell at Wisby, Likershamn, Mid.-Gotland; Djupvik (Eksta), Lilla och Stora Carlsö; Petesvik (Habblingbo), Endre, Hejdeby, Lergraf, Boge, Färo. It occurs also in Ehstland, and in several other districts. Prof. Hall informs us that it is abundant in the upper limestone of the Clinton group at Lockport, Lewiston, and other places in the Niagara country, is less abundant in the same position at Rochester and other eastern localities, and that it is found also in the Niagara shale.

¹ Upper Caradoc, i.e. May Hill sandstone, or Upper Llandovery rock.

PLATE I.

SILURIAN SPECIES.

Fig.

- | | | |
|---------|---------------------------|--|
| 1—11. | <i>Lingula Lesueuri</i> , | Rouault. Lower Silurian. Figs. 1—10, specimens of various ages. "Pebble-bed," Budleigh-Salterton, Devonshire. Collection of Mr. Vicary. Fig. 11, from the Drift near Rowington, Warwickshire. Collection of the Rev. P. B. Brodie. |
| 12, 13. | ,, <i>Bechei</i> , | Salter. Upper Llandovery, Marloes Bay. Fig. 12 <i>a</i> , part of the outer surface, magnified. Mus. Geol. Survey, London. |
| 14—20. | ,, <i>Rouaulti</i> , | Salter. Lower Silurian, Budleigh-Salterton. Collection of Mr. Vicary. |
| 21—26. | ,, <i>Hawkei</i> , | Rouault (?). Same locality and collection. Figs. 21—23, after the original figures by Mr. Salter ('Quarterly Journal Geol. Soc.,' vol. xx, pl. xvii, figs. 2 <i>a</i> , 2 <i>b</i> , 3). Fig. 26 is figured in the same plate (fig. 6) as <i>Lingula Brimonti</i> , Rouault; but the specimen appears to be a modification or malformation of the typical form of <i>L. Hawkei</i> . |
| 27—29. | ,, ? <i>Salteri</i> , | Davidson. Lower Silurian ?, Budleigh-Salterton. Collection of Mr. Vicary. |
| 30. | ,, sp. ? | Perhaps a variety of <i>L. Lesueuri</i> ; but it likewise resembles some specimens of <i>L. crumena</i> . Budleigh-Salterton. |
| 31. | ,, sp. ? | Undetermined, one specimen only having been found. Budleigh-Salterton. Collection of Mr. Vicary. |

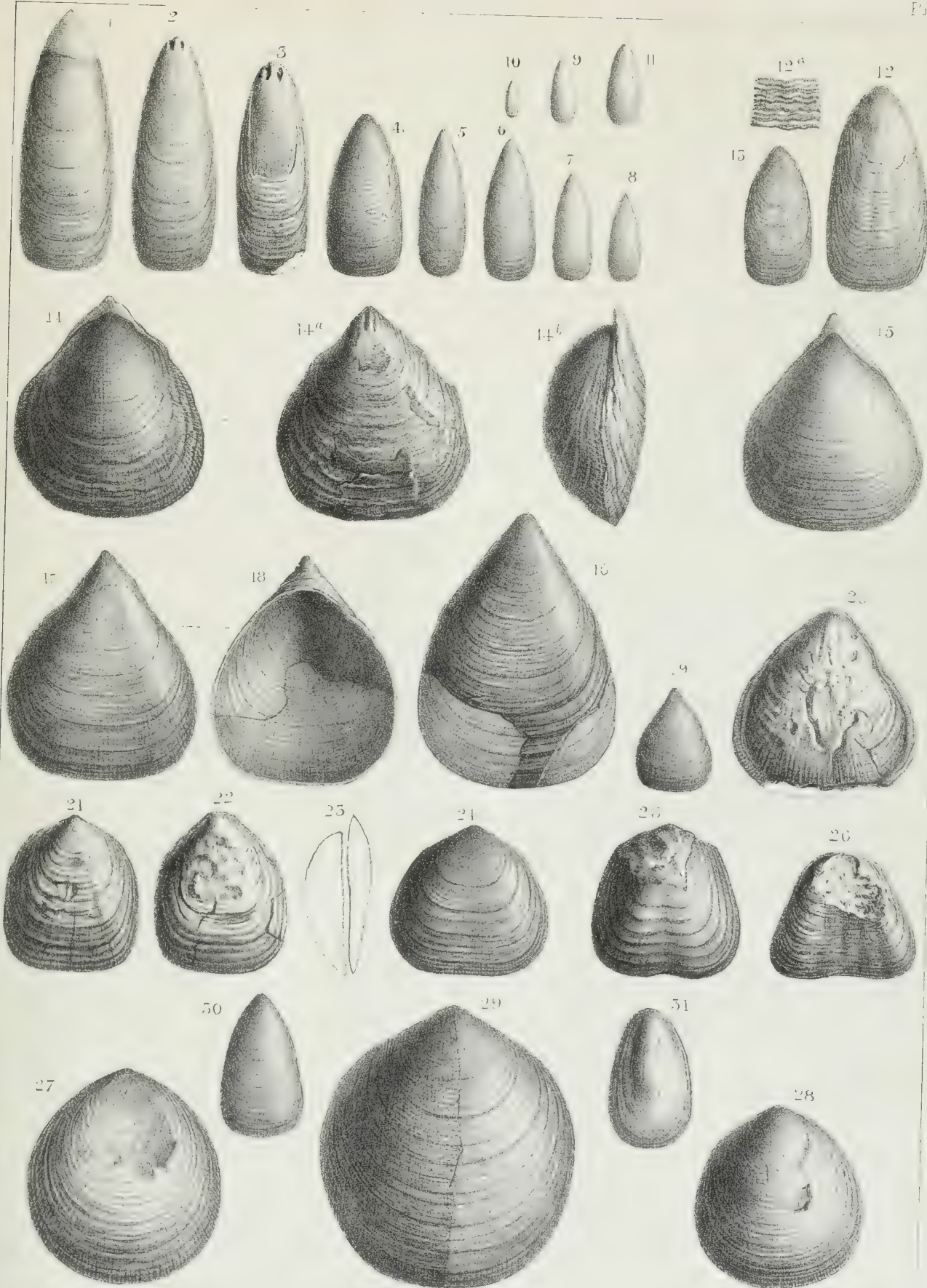


PLATE II.

SILURIAN SPECIES.

FIG.

- 1—6. *Lingula crumena*, Phillips. Various ages and shapes. Lower Llandovery, Howler's Heath. Mus. Geol. Survey, London.
7. „ *squamosa*, Holl. Fig. 7, nat. size. Fig. 7 *a*, enlarged, and slightly restored (described, but not figured in vol. xxi of 'Quart. Journal Geol. Soc. London,' p. 102), from the Hollybush Sandstone of the Malvern Hills. Collection of Dr. Holl.
8. „ *pygmæa*, Salter. After the figure in 'Geol. Journal,' vol. xxi, p. 101. In the Black Shales (Upper Lingula-flags), Malvern.
- 9—14. „ *tenuigranulata*, M'Coy. Fig. 9, original figure (Brit. Pal. Foss., pl. i L, fig. 8). Schists of Alt-yr-Anker, Meyfod. Woodwardian Museum, Cambridge. Figs. 10—14, different specimens from the Bala schists, near Llanfyllin. Figs. 12, 13, Collection of Mr. D. C. Davies. Fig. 11, Peel Park Museum, Salford, Manchester. Fig. 12 *b*, a portion of shell greatly magnified.
- 15—18. „ *granulata*, Phillips. Fig. 15, nat. size. Fig. 15 *a*, magnified, and after original figure ('Mem. Geol. Survey of Great Britain,' vol. ii, pl. xxv), Llandeilo flags, Dynevor Park. Mus. Geol. Survey, London. Fig. 16, a large example from the Middle Llandeilo flags. Llandeilo; Collection of Mr. G. H. Morton. Fig. 17, same locality. Collection of Mrs. Branwell. Fig. 18, from Dynevor Park. Collection of Mr. Wyatt-Edgell.
- 19—23. „ *ovata*, M'Coy. Fig. 19, original figure ('Synopsis Sil. Foss. Ireland,' pl. iii, fig. 1), Caradoc shale, Ballygarvan Bridge, Wexford. Fig. 20, from Caheraneartha, Chair of Kildare. Collection of Sir R. Griffith. Fig. 21, Caradoc-beds, Marshbrook. Collection of Mr. Lightbody. Fig. 23, same formation. Horderly, Salop. Collection of Mr. Wyatt-Edgell.
- 24—27. „ *parallela*, Phillips. Figs. 24, 25, Upper Llandovery, Gunwick Mill. Mus. Geol. Survey, London. Figs. 26, 27, from same formation. Eastnor Park, near Malvern. Collection of Mr. H. Wyatt-Edgell.
- 28—35. „ *cornea*, Sow. Fig. 28, after original figure ('Sil. Syst.,' pl. iii, fig. 3), Passage-beds, Tin Mill, Downton. Mus. Geol. Soc., London. Fig. 29, Passage-beds, Railway, near Ludlow. Figs. 30—34, from the same beds. Mus. Geol. Survey, London. Fig. 32, Brockhill, Ludlow. Mus. Geol. Surv., London. Fig. 33, specimen identified as *L. cornea* ('Synopsis Sil. Foss. Ireland,' p. 24), Ludlow slates, Doonquin (or Dunquin), Dingle, County Kerry: Collection of Sir R. Griffith. Fig. 35, interior (enlarged); Norton, near Ludlow. Collection of Mr. Lightbody.
- 36—44. „ *minima*, Sow. Fig. 36, from the Trochus-bed (Upper Ludlow), Lesmahago, Lanarkshire. Fig. 37, Upper Ludlow (under bone-bed), Ludford Lane, near Ludlow. Fig. 42—44, Uppermost Ludlow, Birkenhead Burn, Lesmahago (*L. unguiculus*, Salter). Mus. Geol. Survey, London. Figs. 38—41, Downton Sandstone. Old Lemster Road, near Ludlow.

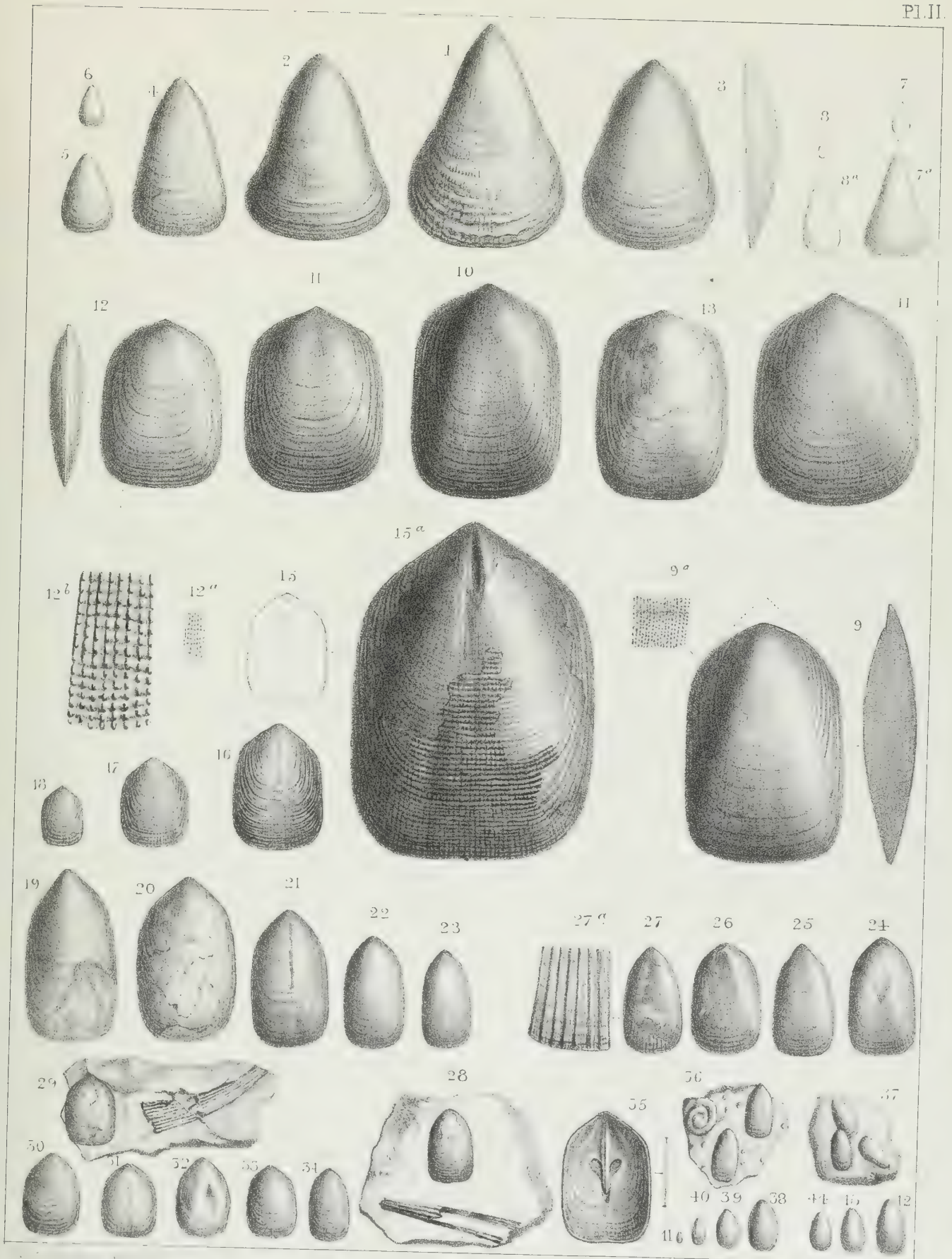


PLATE III.

SILURIAN SPECIES.

FIG.

- 1—6. *Lingula Lewisii*, Sow. Fig. 1, Aymestry limestone, Sedgley, between Dudley and Wolverhampton. Fig. 2, Upper Ludlow, Whitecliff, near Ludlow. Collection of Mr. Lightbody. Fig. 3, Aymestry limestone, near Ludlow. Collection of Rev. H. G. Day. Fig. 4, specimen referred to *L. Lewisii* (?), by Professor McCoy, at p. 24 of 'Synopsis Sil. Foss., Ireland,' and stated to be from Shanballymore, Outerard, County Galway. Collection of Sir R. Griffith. Figs. 5, 6, interior of both valves, from Aymestry limestone, Sedgley.
- 7—17. „ *Symondsii*, Salter. Figs. 7, 8, Lower Ludlow, Ledbury. Mus. Geol. Survey, London. Fig. 9, id. Collection of Dr. Holl. Figs. 10, 11, Wenlock shale, Buildwas, near Wenlock. Mus. Geol. Survey, London. Fig. 12, Wenlock shale, near Dudley. Fig. 13, Upper Llandovery, Penlan, Llandovery. Geol. Survey Mus. Fig. 14, Wenlock shale, from Alfric Pond (base of the die-earth), Malvern. Mus. Geol. Soc. Fig. 15, Woolhope limestone, The Wych, Malvern. Fig. 16, id., Sandbanks, Presteign. Fig. 17, Upper Llandovery, Mandinam, Llandovery. Figs. 15—17, Mus. Geol. Surv., London.
- 18—27. „ *attenuata*, Sow. Fig. 18, after original figure ('Sil. Syst.,' pl. xxii, fig. 13), Llandeilo flags, Llandeilo and Shelve. Mus. Geol. Soc. Fig. 19, same locality. Fig. 20, Coed Sion Llangadoc. Both in Mus. Geol. Survey, London. Figs. 21, 22, Shelve. Collection of Mr. Morton. Fig. 23, Upper Llandeilo, West of Meadowtown. Collection of Mr. Lightbody. Fig. 24, 25, Balclatchie, Girvan, Ayrshire. Fig. 26, Builth. Collection of Mr. Morton. Fig. 27, small specimen ('Sil. Syst.,' pl. xxii, fig. 13), Llandeilo flags, Rorington, Salop. Mus. Geol. Soc., London.
- 28—30. „ *longissima*, Pander? Fig. 28, from Caradoc shales, Moelydd, Wales. Collection of Mr. D. C. Davies. Fig. 29, from Ketch Bridge, near Llanfyllin. Collection of Mr. Prosser. Fig. 30, specimen described as *L. longissima*, at p. 253 of 'Brit. Pal. Foss.' Woodwardian Museum, Cambridge.
- 31, 32. „ *obtusa*, Hall? Fig. 31, specimen so identified and described by Prof. McCoy, 'Brit. Pal. Foss.,' pl. iii, p. 253. Fig. 32, Caradoc beds, Marshbrook, Salop. Collection of Mr. Wyatt-Edgell. [Are not these two specimens referable to *L. ovata*, McCoy?]]
33. „ *attenuata*, Sow.? Specimen described as *L. curta*, Conrad, in 'Brit. Pal. Foss.,' p. 251. Bala flags, Wellfield, Builth. Woodwardian Mus., Cambridge.
- 34—39. „ *brevis*, Portlock. Fig. 34, original figure ('Geol. Rep. of Londonderry, &c.,' p. 443, pl. xxxii, fig. 2), Caradoc beds, Desertcreat, Tyrone. Fig. 35, Skiddaw slates, Outerside, near Keswick, Cumberland. Collected by Prof. Harkness. Fig. 36, specimen labelled "*L. brevis*," by Portlock. Desertcreat, Tyrone. Mus. Geol. Survey, London. Figs. 37—39, specimens named "*L. brevis*," in Mus. Geol. Survey, Ireland. Fig. 37, same locality. Fig. 38, Newton Head, Waterford. Fig. 39, Tramore, Waterford.
- 40—44. „ *lata*, Sow. Fig. 40, original specimen (Sil. Syst., pl. viii, fig. 11), Lower Ludlow, Elton. Mus. Geol. Soc., London. Fig. 41, another example, from the same locality. Fig. 42, Ludlow shale. Pentland Hills. Collection of Mr. D. J. Brown. Fig. 43, Ludlow, Hale's End, near Malvern. Collection of Dr. Holl. Fig. 44, Lower Ludlow, Vinnal Hill, Ludlow.
- 45—48. „ *striata*, Sow. Fig. 45, after original figure ('Sil. Syst.,' pl. viii, fig. 12), Lower Ludlow, Aymestry. Mus. Geol. Soc. Fig. 46, Lower Ludlow, Ledbury. Mus. Geol. Survey, London. Figs. 47, 48, Wenlock shale, Dudley. Same Museum.
- 49—52. „ *Ramsayi*, Salter. Fig. 49 ('Siluria,' 2nd ed., p. 55, Foss. 10, fig. 20, reduced figure), Llandeilo flags, Abereiddy Bay, Pembrokeshire. Figs. 50—52, same locality. Mus. Geol. Survey, London. Fig. 51, ib. Collection of Mr. Lightbody.
- 53—59. „ (*Lingulella*) *lepis*, Salter. Figs. 53—56, after original figures ('Mem. Geol. Survey,' vol. iii, p. 334), from Lower Tremadoc, Borth Wood, Portmadoc, and Mus. Geol. Survey, London. Fig. 57, interior. Fig. 57a, enlarged figure. Same locality and Museum. Figs. 58, 59, distorted specimens. Fig. 59, Moel-y-Gest, Tremadoc, north-west side. Geol. Survey Museum.

SILURIAN

Pl. III.

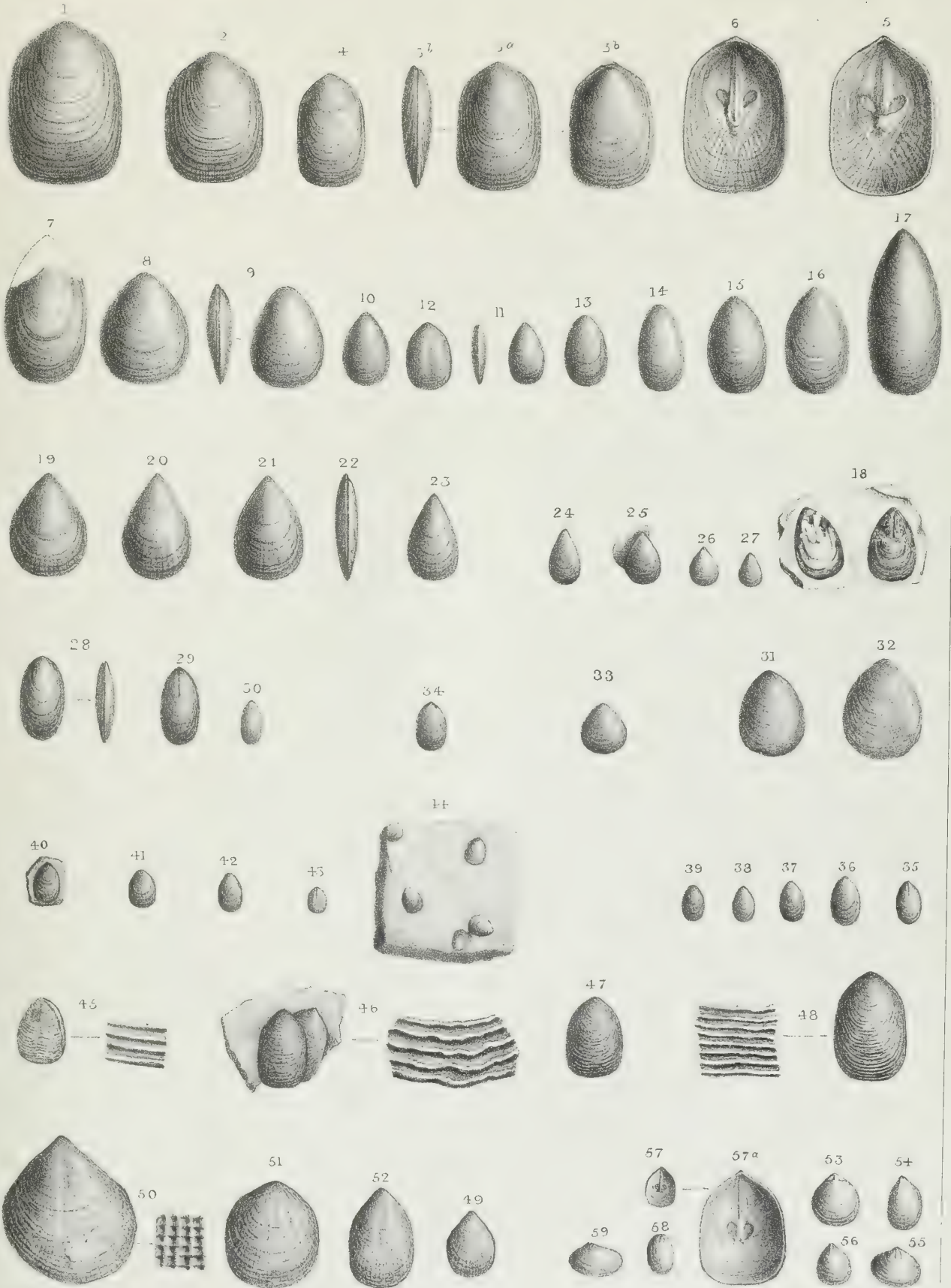


PLATE IV.

SILURIAN SPECIES.

FIG.

- 1—16. *Lingulella Davisii*, Salter. Figs. 1, 2, Lower Lingula-beds, Pen-y-Bryn, five miles north of Dolgelli. Mus. Geol. Survey, London. Figs. 3—7, 9, 13, 14, 15, figures of different specimens, reproduced from vol. iii, pls. ii and iv of 'Mem. Geol. Survey, London,' Lingula-beds, North Wales. The specimens are in the Mus. Geol. Survey, London. Fig. 8, Upper Lingula-flags, Tremadoc. Collection of Mr. Morton. Figs. 10, 11, elongated specimens, distorted by cleavage. Lingula-flags, Penmorfa, Tremadoc. Mus. Geol. Survey, London. Fig. 12, from Bellewstown, County Meath. Mus. Geol. Survey of Ireland. Fig. 13, distorted examples, formerly referred to *Tellinomya*. Fig. 14, internal cast, nat. size. Fig. 15, portion of same, enlarged. Fig. 16, interior (enlarged), from a mould in gutta-percha taken from an internal cast.
- 17—19. *Obolella ? Phillipsii*, Holl. Fig. 17, nat. size. Fig. 17 *a, b, c*, the same enlarged. Hollybush Sandstone (Middle Lingula-beds), Malvern District. Collection of Dr. Holl. Figs. 18, 19, two valves from same locality and collection.
- 20—27. „ ? *plumbea*, Salter. Figs. 20, 21, after original figures ('Mem. Geol. Survey,' vol. iii, pl. xi B). Figs. 10, 10 *a*, Lower Landeilo Rocks, west of Stiper Stones. Figs. 22, 23, internal cast, showing muscular impressions. Hell Pool, Wyeford, Builth. Fig. 24, a large example. Figs. 21—24, in Mus. Geol. Survey, London. Figs. 25, 26, from Shelve. Collection of Mr. Morton.
- 28, 29. „ ? *Salteri*, Holl. Figs. 28, after original figures, 'Quart. Journal Geol. Soc.,' vol. xxi, p. 102; Upper Lingula-beds, near Coalhill, end of Malverns. Fig. 29, Upper Lingula-flags, White-leaved Oak, near Malvern. Collection of Mr. Wyatt-Edgell.
- 30—39. *Obolus Davidsoni*, Salter. Fig. 30, a bivalve example, slightly restored. Wenlock shale, near Dudley. Fig. 31, interior of ventral valve. Fig. 32, interior of dorsal valve from moulds in gutta-percha, taken from internal casts. Figs. 33—35, internal casts of the two valves, Wenlock shales, Rushall Canal, near Walsall. Mus. Geol. Survey, London. Figs. 36, 37, casts; same locality. Collection of Mr. L. P. Capewell. Fig. 38, another cast from same locality. Mus. Geol. Survey, London. Fig. 39, from Wenlock Shale, near Dudley.



PLATE V.

· SILURIAN SPECIES.

FIG.

- 1—6. *Obolus Davidsoni*, var. *transversus*, Salter. Figs 1, 2, flattened impressions in Wenlock shale from Parker's Hall, near Dudley. Fig. 1, in Mus. Geol. Survey, London. Fig. 3, impression, from same locality, showing on its surface numerous indentations produced by small spines. Collection of Mr. Mushen. Fig. 4, a large cast from same locality; in the collection of Mr. L. P. Capewell. Fig. 5, cast of one valve uncompressed. Fig. 6, internal cast, from Rushall Canal, Walsall. Collection of Mr. Mushen. This shell occurs also in the Wenlock limestone, but not so abundantly as in the shales.
- 7, 8. „ „ var. *Woodwardii*, Salter. Fig. 7, a fragment, labelled *O. Woodwardii* in Mus. Geol. Survey, London; from Wenlock limestone, Dormington Wood, Woolhope. Fig. 8, another specimen in the same Museum, from Wenlock shales, near Dudley.
- 9—18. *Discina rugata*, Sow. Figs. 9, 10, after original figures ('Sil. Syst.,' pl. v, fig. 11), Upper Ludlow, Ludlow; Mus. Geol. Soc. Fig. 11, attached valve, Upper Ludlow, Whitecliff Ludlow. Fig. 12, Lower Ludlow, Church Hill. Collection of Mr. Lightbody. Fig. 13, a finely preserved upper valve, from Upper Ludlow, Sunnybank, near Ludlow. Fig. 14, Upper Ludlow, Combe Hill; Mus. Geol. Survey, London. Fig. 15, Upper Ludlow, Delbury; Mus. Geol. Soc. Fig. 16, near Ludlow. Fig. 17, Ludlow. Fig. 18, Wenlock shale, Parker's Hall, near Dudley. Collection of Mr. L. P. Capewell.
- 19—24. „ *perrugata*, M'Coy. Fig 19, after original figure ('Synopsis Sil. Foss. Ireland, pl. iii, fig. 2), from sandstone, Kilbride, Cong, County Galway. Collection of Sir R. Griffith. Fig. 20, from Caradoc beds, Chair of Kildare; Mus. Geol. Survey, London. Fig. 21, a large flattened impression, from Caradoc beds, Desertcreat, Tyrone; same Museum. Fig. 22, Upper Llandovery beds?, Penlan, near Llandovery. Collection of Mr. Wyatt-Edgell. Fig. 23, from Balceltchie, Girvan Valley, Ayrshire.

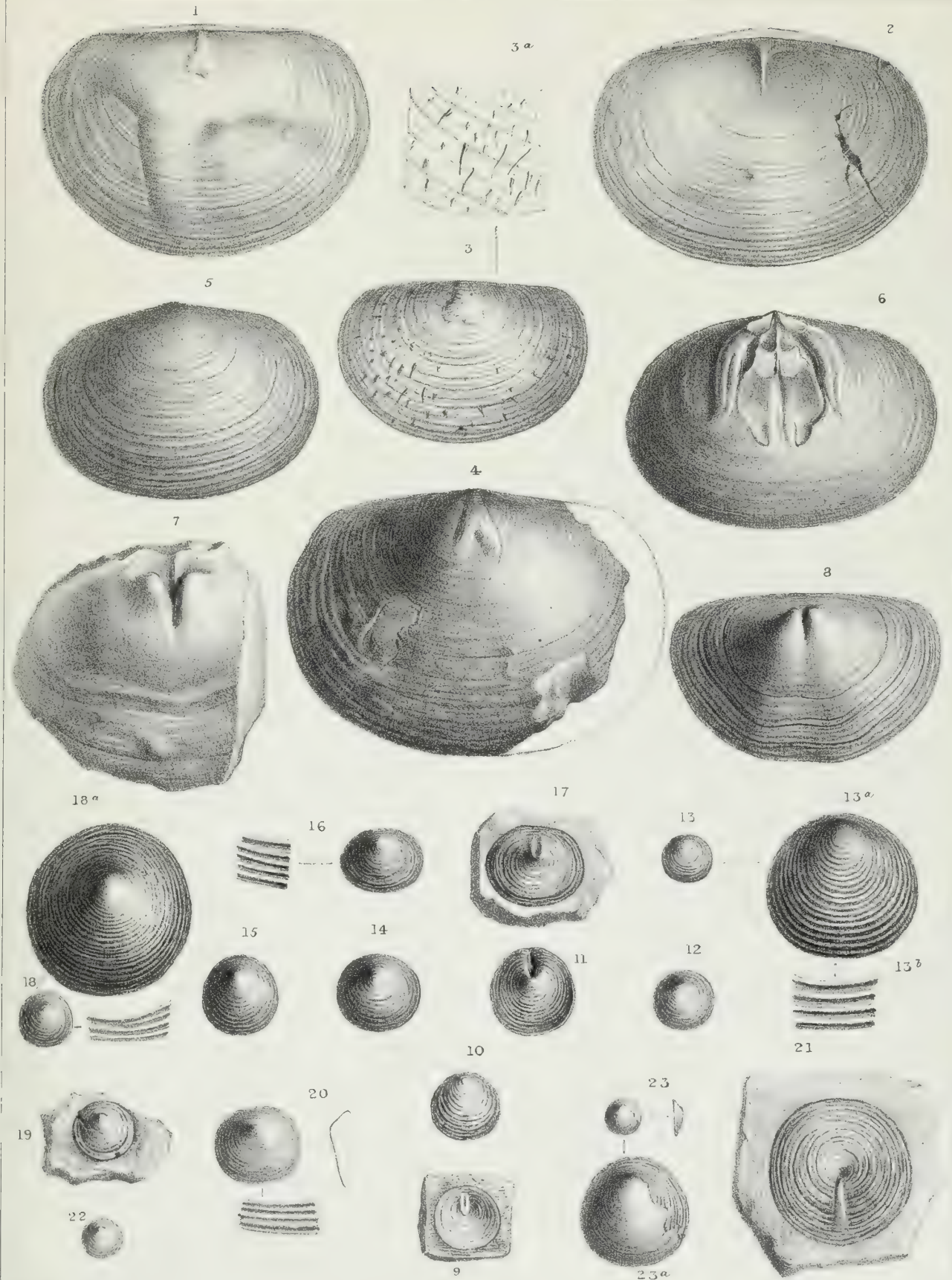


PLATE VI.

SILURIAN SPECIES.

FIG.

- 1—4. *Discina striata*, Sow. Fig. 1, after original figure ('Sil. Syst.,' pl. v, fig. 11), Upper Ludlow, Delbury, Shropshire; Mus. Geol. Soc. Fig. 2, a large specimen from Upper Ludlow, Whitecliff, near Ludlow. Collection of Mr. Marston. Fig. 3, Murchison's original specimen (fig. 1). [The striæ are so fine and close on the specimen, that they can hardly be detected with the naked eye, and are, consequently, too large on the figure. The enlarged fig. 3 *a* shows them better.] Fig. 4, an elongated example; Upper Ludlow, Whitecliff. Collection of Mr. Lightbody.
5. ,, *Verneuillii*, Dav. Original specimen, from Wenlock limestone, Stoney Hill, near Ledbury. Sharpe's collection, Mus. Geol. Soc.
- 6, 7. ,, *crassa*, Hall. ? Fig. 6, from Llandeilo flags, Builth. Fig. 7, from Penwhapple Glen, Ayrshire. Both in the Mus. Geol. Survey, London.
8. ,, (*Trematis*) *Siluriana*, Dav. Fig. 8, natural size; Caradoc beds, Horderley. (This beautiful specimen was presented to the Mus. Geol. Survey, London, by Mr. E. H. Birkenhead.) Fig. 8 *a*, a considerably enlarged figure of the free or upper valve. Fig. 8 *b*, a portion of the shell still more enlarged so as to show better the character of the sculpture.
9. ,, (*Trematis*) *punctata*, Sow. Fig. 9, natural size, from Caradoc sandstone, Cheney Longville Lane, Shropshire; Mus. Geol. Survey, London. Figs. 9 *a* and *b*, considerably magnified illustrations in which the shell-sculpture has been carefully completed from perfect portions visible here and there on a specimen from the Caradoc beds of Hope Bowdler, near Church Stretton, Shropshire, in Museum Geol. Survey, London; and from another example in the Collection of Mr. Lightbody. Fig. 9 *c* shows the sculpture still more enlarged.

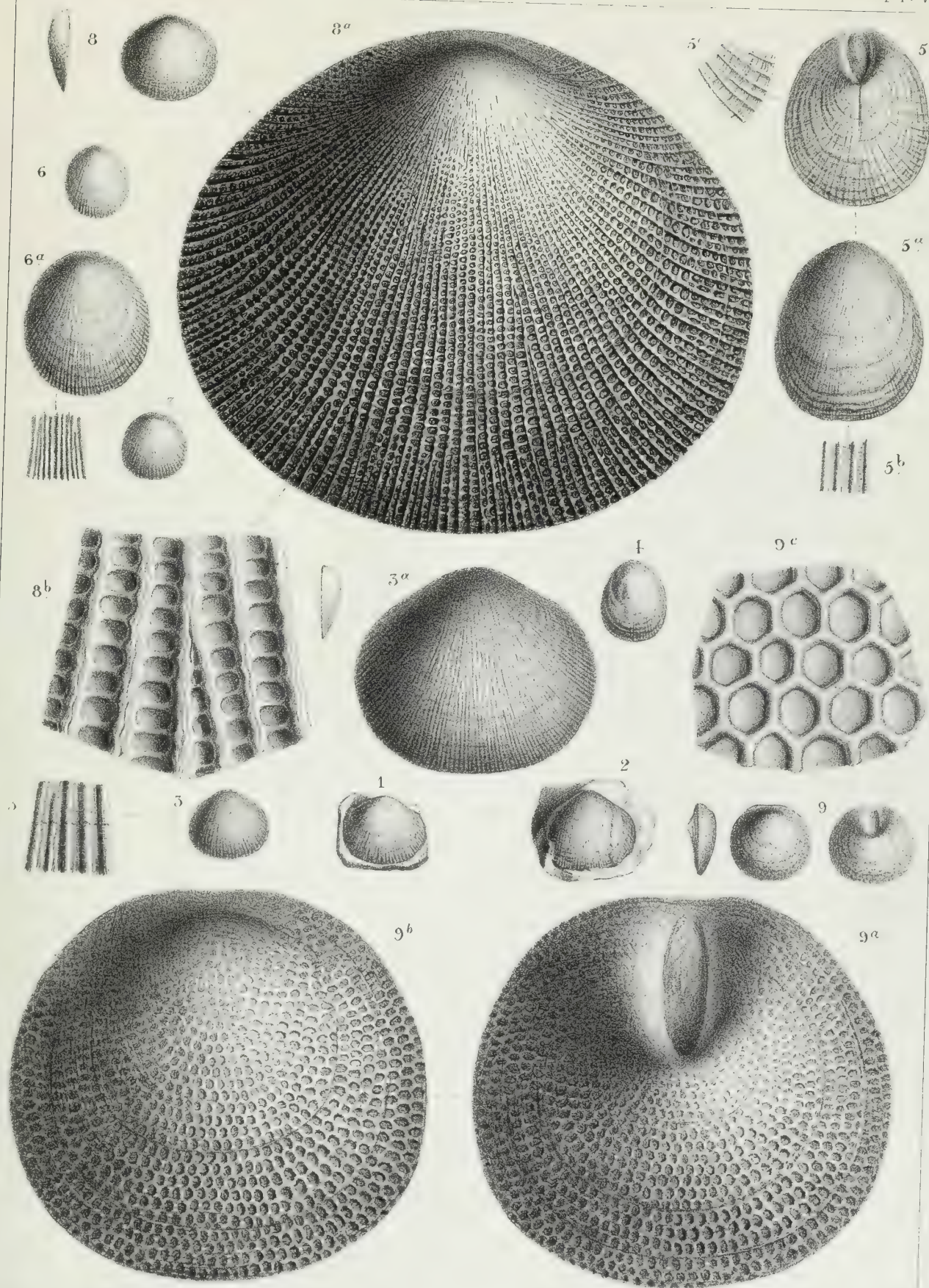


PLATE VII.

SILURIAN SPECIES.

FIG.

- 1—9. *Discina oblongata*, Portlock. Figs. 1 and 2 are drawn from the two original specimens figured by Portlock, under the designation of “*Orbicula lævigata*, Münster;” from the Caradoc beds of Desertcreat, Tyrone. Mus. Geol. Survey, London. Fig. 3, from Caradoc beds of South Shropshire. Collection of Mr. D. C. Davies. Figs. 4, 5, from New Girvan, Ayrshire. Geol. Survey Mus. Figs. 6 and 7 are taken from Portlock’s original examples of *D. subrotunda*. Caradoc beds, Desertcreat, Tyrone. Mus. Geol. Survey, London. Fig. 8, after Portlock’s original figure of *D. oblongata* (‘Geol. Rep.,’ pl. xxxii, fig. 13). Fig. 9, from Bardahessiagh, Pomeroy, County Tyrone. Collection of Sir R. Griffith.
- 10—12. „ *Morrisii*, Dav. From Wenlock limestone, Dudley; and Aymestry limestone, Sedgley. Fig. 12, in Mus. Geol. Survey, London.
13. „ ? *Vicaryi*, Dav. Cast of upper valve; Lower Silurian (?), Pebble-bed, Budleigh - Salterton, Devonshire. Collection of Mr. Vicary.
- 14—18. *Orbiculoidea Forbesii*, Dav. Figs. 14, 15, two very fine examples of the foraminated valve, from Wenlock limestone, Winnal’s Farm, Malverns; Mus. Geol. Survey, London. Fig. 16, a large, very gibbous upper valve, from Wenlock limestone, Dudley. British Museum. In fig. 16 *a*, the lower or foraminated valve has been added to show how the shell would appear when complete; under this figure is another smaller and perfect specimen. Fig. 17, a small example from Wenlock shales, Rushall Canal, near Walsall. Fig. 18, from Llandeilo flags, Shelve. Collection of Mr. Morton. It is not, however, quite certain that this last really belongs to *O. Forbesii*, although the resemblance is great.
19. „ ? *Beckettiana*, Dav. Wenlock limestone?, Wren’s Nest, Dudley. Collected and presented to the Mus. Geol. Survey, London, by Mr. H. Beckett.

SILURIAN.

Pl VII

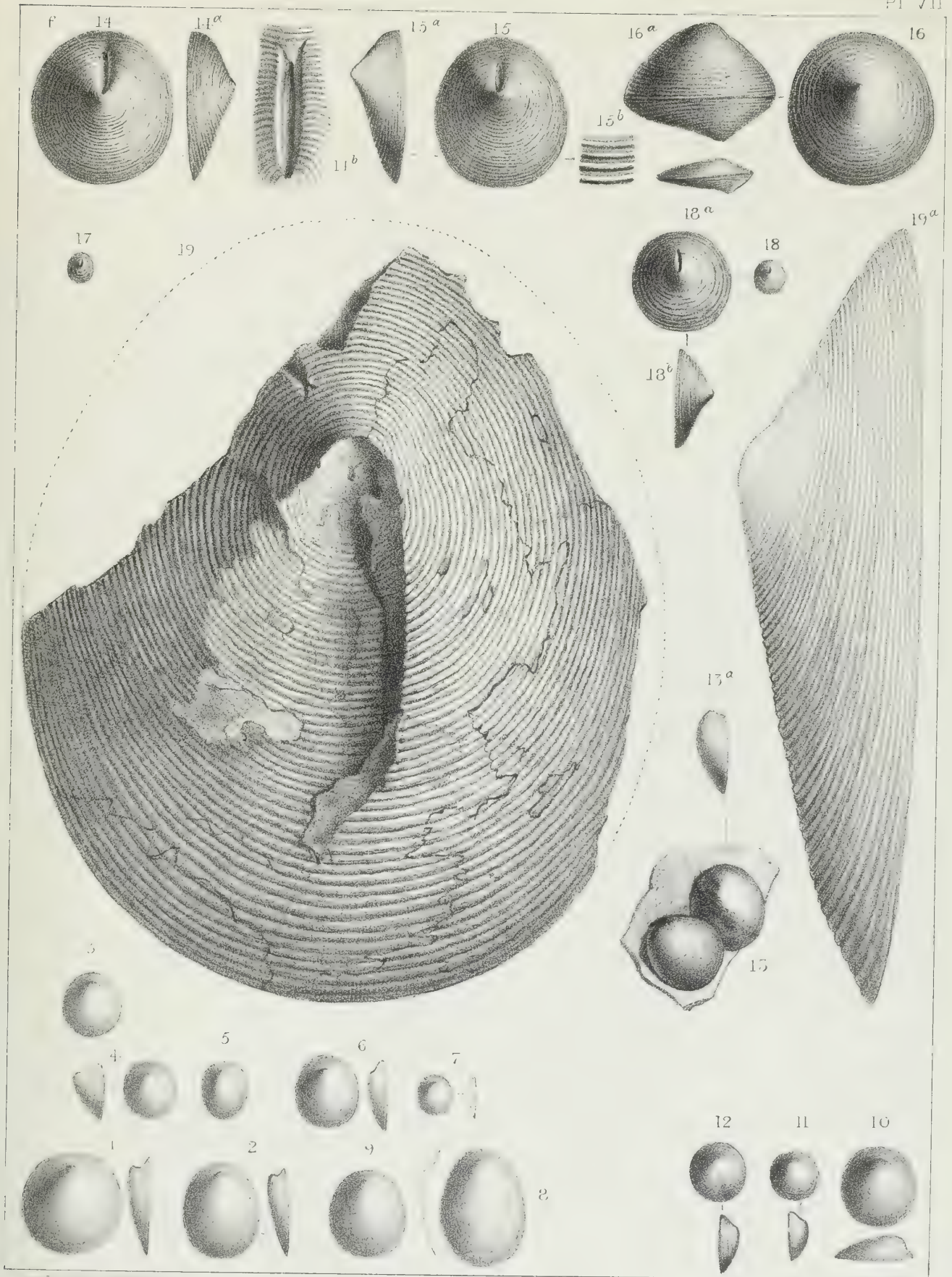


PLATE VIII.

SILURIAN SPECIES.

FIG.

1. *Siphonotreta Anglica*, Morris. Original figure ('Annals and Mag. of Nat. Hist.,' 2nd ser., vol. iv, pl. vii, fig. 1. Fig. 1, shell natural size; *a*, magnified view; *b*, outer surface magnified; *c*, spine enlarged. Wenlock shale, Dudley. Collection of Mr. J. Gray.
- 2—6. „ *micula*, M'Coy. Fig. 2, original figure ('British Pal. Foss.,' pl. i H, fig. 3), natural size; 2*a*, enlarged. Llandeilo flags, near Builth. Woodwardian Museum, Cambridge; Fig. 3, natural size; 3*a*, enlarged. Llandeilo flags, Wye Ford, Builth. Mus. Geol. Survey, London. Fig. 4, Glenkiln, Dumfriesshire; Llandeilo flags. Mus. Geol. Surv., London. Fig. 5, Builth. Collection of Mr. Morton. Fig. 6, Balclutchie, Ayrshire.
- 7—12. *Crania divaricata* (*Pseudocrania*) M'Coy. Fig. 7, internal cast of ventral valve, after original figure ('Brit. Pal. Foss.,' pl. i H, fig. 2); from the Upper Bala Rocks of Bryn Melyn Quarry, Bala. Woodwardian Museum, Cambridge. Fig. 8, exterior, op. cit., pl. i H, fig. 1. Fig. 9, internal cast of ventral valve, natural size; from Caradoc beds, Penny Park, near Llanfyllin, Montgomeryshire. Collection of Mr. W. Prosser. Fig. 9*a*, enlarged, gutta-percha mould from cast, showing the interior of ventral valve, its muscular and other impressions. Fig. 10 *a*, exterior of one valve, enlarged; Caradoc beds, Chair of Kildare, Ireland. Fig. 11, internal cast of dorsal valve, with muscular impressions; *a*, occlusor; *l*, dorsal adjustor; *r*, divaricator; *m*, mesenteric; *n*, brachial (anterior extremities): fig. 11 *a*, the same enlarged. Figs. 12 and 12 *a*, an enlarged interior of valve, taken from a gutta-percha mould made from internal cast, fig. 11*a*; Chair of Kildare. Mus. Geol. Survey, London.
- 13—17. „ *implicata* (*Patella*), Sow.¹ Fig. 13, after the original figure., 'Sil. Syst.,' pl. xiv, fig. 12; Wenlock limestone, Abberley. Mus. Geol. Soc., London. Fig. 14, natural size, Wenlock limestone, Rock Farm, May Hill. Fig. 14 *a*, *b*, the two valves enlarged; *c*, profile view of both valves. Fig. 15, interior of ventral valve enlarged; same locality. Fig. 16, slab covered with small internal casts, Upper Ludlow beds, Newton Lane, Bradna Hill. Geol. Mus. Survey, London. Fig. 16 *a*, one of these casts enlarged. Fig. 17, Upper Llandovery, Mandinan, Llandovery; same museum.
18. „ „ ? Upper Ludlow beds, Pentland Hills. Collection of Mr. D. J. Brown.
- 19, 20. „ *Siluriana*, Dav. Fig. 19, two exteriors on a specimen of *Leptæna Waltoni*, from Wenlock shale, Falfield. Fig. 20, interior of one of the valves.
21. „ ? Species undetermined. One specimen from Caradoc sandstone, Gretton, Salop. Collection of Mr. Wyatt-Edgell.
- 22—24. „ ? *Grayii*, Dav. Fig. 22, five exteriors of upper valve, attached to a specimen of *Spirifera plicatella*, var. *radiata*, from Wenlock limestone, Rushall Canal. British Museum. Fig. 23, a large example, and fig. 24 *a*, enlarged figure; from Wenlock limestone, Dudley. Collection of Mr. L. P. Capewell.
25. „ ? *Sedgwicki*, Lewis. (Genus undetermined, and no longer considered even a Brachiopod. Might it be referable to some Coral?) The original specimen; Wenlock limestone, Rushall Canal, near Walsall. Mus. Geol. Survey, London. Fig. 25 *a*, inner surface enlarged.
- 26, 27. *Spondylolobus craniolaris*, M'Coy. After original figures ('Brit. Pal. Foss.,' pl. i H, figs. 4 and 5); and explained as follows:—Fig. 26, exterior. Fig. 27, group of three casts of inner surface of large valve, natural size, from the black shale of Builth Bridge. Fig. 14 *c*, wax cast from one of ditto, showing the appearance of the shell magnified. (This fossil will hereafter be referred to and explained.)
28. *Goniophyllum pyramidale* (*Turbinolia*), Hisinger. Wenlock shale, Dudley. Collection of Mr. L. P. Capewell. This is the first British specimen of the species hitherto discovered, and is here figured because the fossil had, by Girard (Leonh. und Bronn's 'Jahrbuch,' 1843, p. 232), been considered to be a *Calceola*; a view subsequently rejected by Milne-Edwards, J. Haime, and Lindström; the genus *Calceola* itself is no longer classed amongst the Brachiopoda.

¹ While describing this species (in a footnote) I mentioned that Prof. Hall had, in 1859, proposed the generic designation of *Photidops* for shells agreeing with *Patella implicata*, Sow.; but I omitted to observe that should these free or unattached species of *Crania* require to be classed under a separate generic designation, that the term *Pseudocrania*, proposed by M'Coy in 1851, would claim priority.



PLATE IX.

SILURIAN SPECIES.

FIG.

- 1—6. *Spirifera plicatella*, var. *radiata*, Sow. 1. After original figure ('Sil. Syst.', pl. 12, fig. 6.) Wenlock Limestone, Malvern Hills. Mus. Geological Society, London. Fig. 2, a large example, Dudley. Collection of Mr. Fletcher. Fig. 2 *a*, portion of shell, considerably magnified. Figs. 3, 4, 5, small examples; same locality. Fig. 6, interior of ventral valve.
- 7—8. ,, ,, var. *globosa*, Salter. Fig. 7, a very large example from Wenlock Limestone, Dudley. Collection of Mr. Fletcher. Fig. 8, same locality.
- 9—12. ,, ,, Linnæus, sp. = *Spirifer interlineatus*, Sow. *Delthyris cyrtæna*, Dal., His., &c. Fig. 9, after original figure of *Sp. interlineatus*, Sow. ('Sil. Syst.' pl. vi, fig. 6.) Aymestry Limestone, Aymestry, &c. Mus. Geol. Soc., London. Fig. 10, from Wenlock Limestone, Benthall Edge. Collection of Dr. Holl. Fig. 11, Wenlock Shale, near Dudley. Fig. 12, Wenlock Limestone, May Hill. Mus. Geol. Soc., London.
- 13—24. *Cyrtia exporrecta*, Wahl., sp. = *C. trapezoidalis*, His. Figs. 13—17, different shapes from Wenlock Limestone, Dudley. Fig. 18, Lower Ludlow, Dog Hill, Ledbury. Mus. Geol. Survey, London. Figs. 19—21, enlarged deltidiums, to show their peculiar shape, and circular foramen, when it exists. Fig. 24, internal casts of dorsal valve from Ludlow Shales, Pentland Hills. Fig. 22, internal cast of ventral valve; fig. 22 *a*, enlarged. Same locality and Collection. Fig. 23, another internal cast of same valve, showing the wide triangular area. Ludlow Shale, Pentland Hills. Collection of Mr. D. J. Brown.

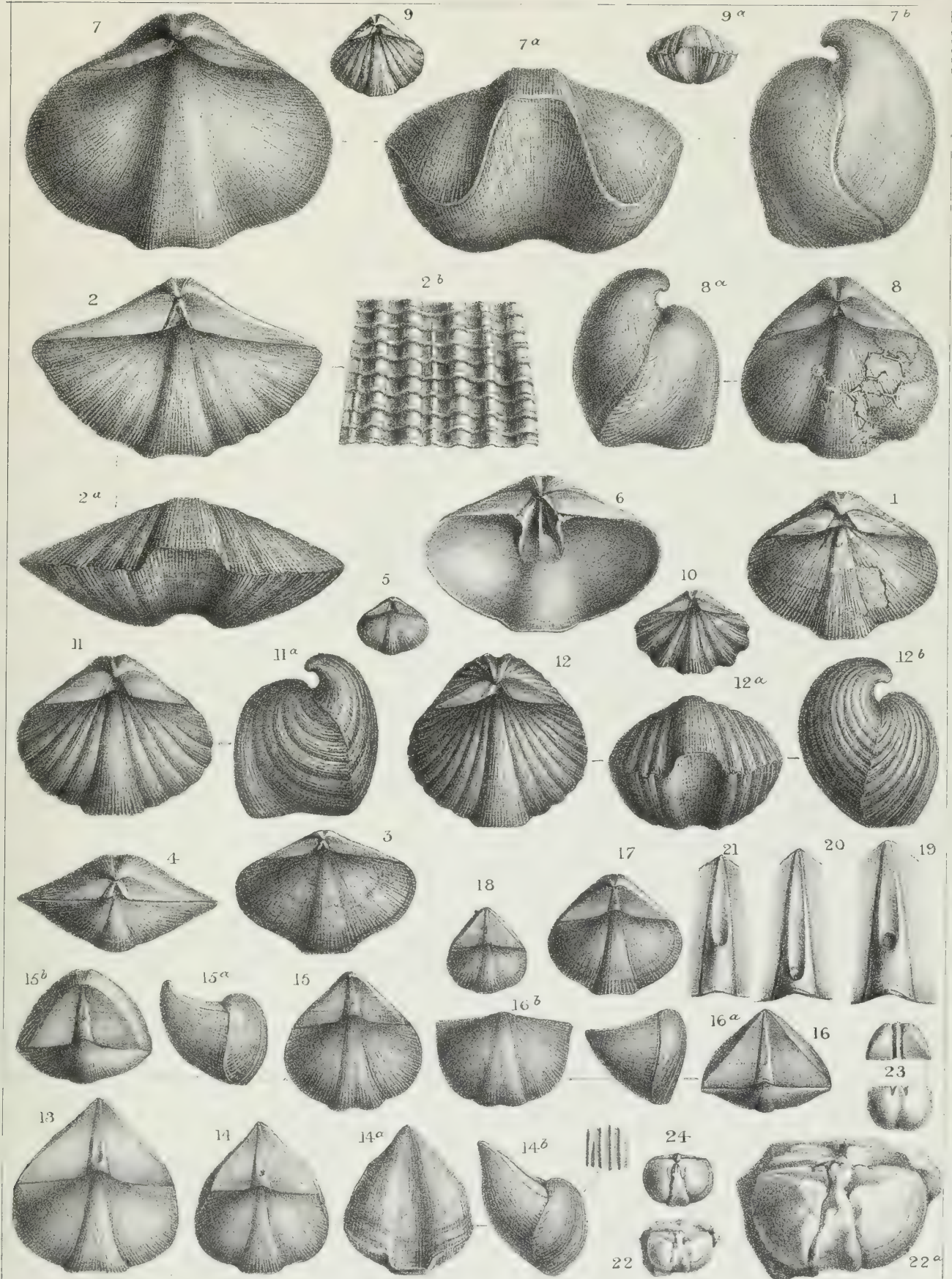


PLATE X.

SILURIAN SPECIES.

FIG.

- 1—3. *Spirifera bijugosa*, M'Coy. Fig. 1, after original figure ('Synopsis Sil. Foss. Ireland,' pl. iii, fig. 23). Wenlock Shale; Doonquin or Dunquin, County Kerry, Ireland. Collection of Sir R. Griffith. Fig. 2, Wenlock beds; Ferriter's Cove, Dingle, County Kerry. Mus. Geol. Survey, Ireland. Figs. 3 and 3 *a*, shell accurately restored from several complete valves in the same Collection, no perfect bivalve specimen having to my knowledge been hitherto discovered.
- 4—6. „ *sulcata*, His. (According to Lindström, the real *Anomia crispa* of Linnæus. Mus. Tess., pl. v, fig. 7, 1753.) Fig. 4, nat. size. Fig. 4 *a*, *b*, enlarged. Wenlock Limestone, Dudley. Fig. 5, a very large example from the same locality. Fig. 6, enlarged figure of a less transverse specimen.
- 7—11. „ *elevata*, Dalman. Figs. 7, 8, Wenlock Limestone, Dudley. Fig. 9, Upper Llandovery beds, Damory Bridge, Tortworth. Fig. 10, Lower Ludlow, Crews Hill, Alfrick. Fig. 11, Wenlock Limestone, Wenlock Edge. (This last specimen seems intermediate in shape between the true *Sp. elevata* and *Sp. crispa* of Hisinger.) Figs. 9—11, Mus. Geol. Survey, London.
12. „ *crispa* (*Anomia crispa*), Linnæus. After the original figure Mus. Tess., pl. v, fig. 7, 1837, and so named in the 'Systema Naturæ.' (Although this figure is not good, it is here reproduced that the student may know what was the original figured form of *Anomia crispa*.) Wenlock Limestone, Gothland.
13. „ „ (*Delthyris crispus*, Hisinger). After the original figure, 'Lethæa Suecica,' pl. xxi, fig. 5. Wenlock Limestone, Gothland. (This also is here given for the sake of reference, as it is believed by some palæontologists that the *Anomia crispa*, Linnæus, and *Delthyris crispus*, His., belong to distinct species.)
- 14, 15. „ „ His. Fig. 14, Wenlock Limestone, Rock Farm, May Hill. Mus. Geol. Survey, London. Fig. 14 *a* enlarged. Fig. 15, Wenlock Limestone, Dudley.
- 16—20. *Nucleospira pisum* (*Sp. pisum*), Sow. Fig. 16, after original figure ('Sil. Syst.,' pl. xiii, fig. 9); Wenlock Limestone, May Hill, near Walsall. Fig. 17, a large example (without spines), W. L., Benthall Edge. Fig. 17 *a*, *b*, *c*, enlarged figures. Figs. 18, 19, from same locality, showing the spiral coils, through the transparency of the fossil shell. Fig. 18 *a*, enlarged. Fig. 20, a specimen still preserving almost all its spiny investments; from the Wenlock Limestone of Colwall Copse. Collection of Dr. Holl; similar examples occur in the Worcester Nat. Hist. Museum.
- 21—27. *Meristella angustifrons* (*Hemithyris*), M'Coy. Fig. 21, after original figure ('Brit. Pal. Foss., pl. i H, fig. 5), from the Caradoc Sandstone at Dalquorhan, Ayrshire. Figs. 22—24, Caradoc beds; Penhill and Mullock Hill, Ayrshire. Fig. 25 *a*, specimen showing portions of spiral coils; same locality. Figs. 26, 27, internal casts; Girvan Valley, Ayrshire. Figs. 26 *a*, *b*, enlarged figures.
- 28—31. „ *læviuscula* (*Terebratula*), Sow. = (*Atrypa nitida*, Hall.) Fig. 28, Wenlock Limestone, Dudley. Mus. Geol. Survey, London. Fig. 29, same locality. Fig. 30, Wenlock Shale; Rushall Canal, near Walsall. Fig. 31, a specimen showing traces of internal spiral coils. Fig. 31, after the original figure of *T. læviuscula*, Sow. ('Sil. Syst.,' pl. xiii, fig. 14.) Wenlock Shale, Tynewydd, Llandovery. Mus. Geol. Soc.
- 33—35. „ *Circe*, Barrande. Fig. 33, from Wenlock Limestone, Dudley. Fig. 34, Woolhope Limestone, Eastnor Park, Malvern. Collection of Dr. Holl. Fig. 35, specimen showing portions of spiral coils, Dudley.

SILURIAN.

PL. 11

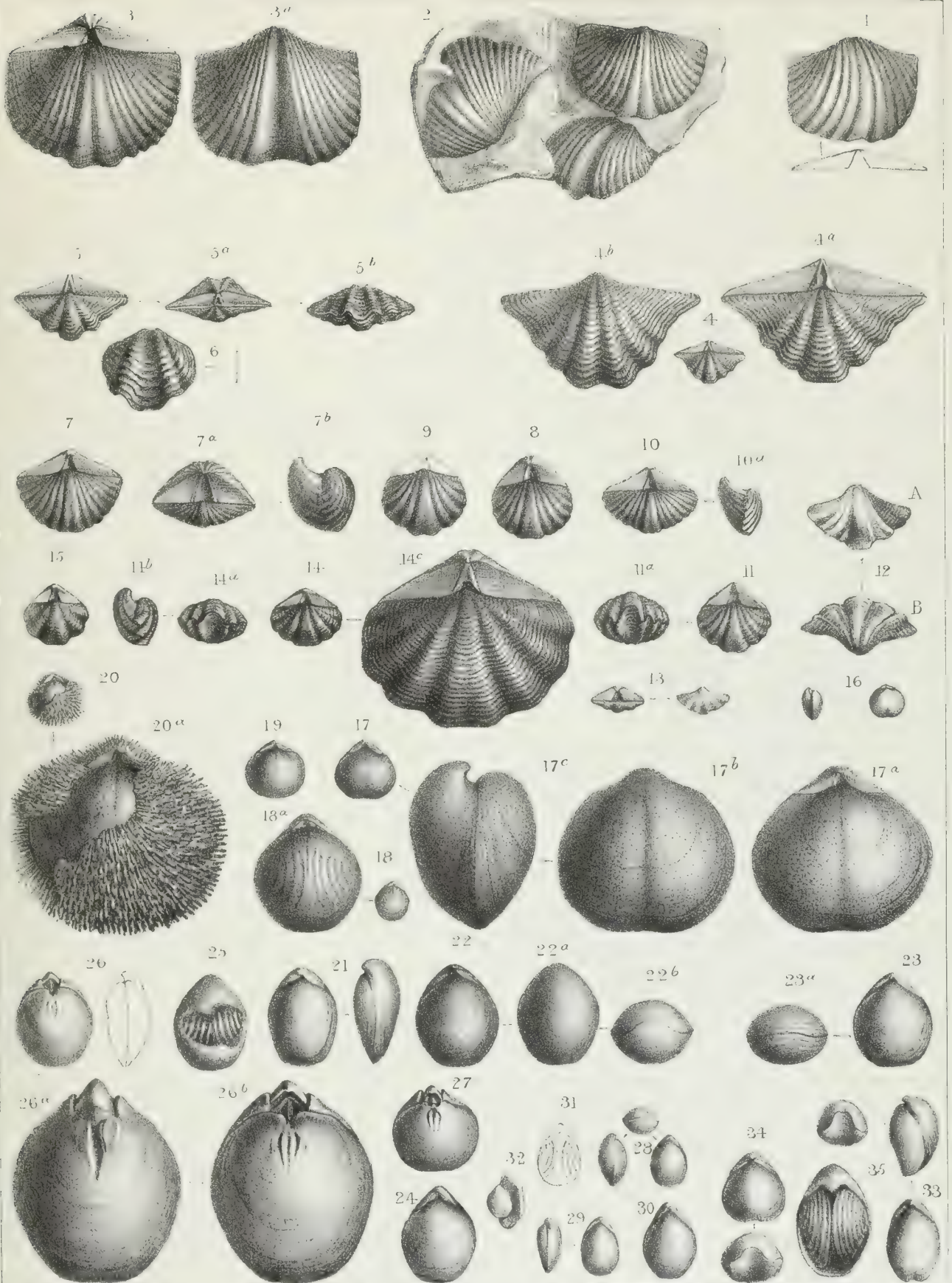


PLATE XI.

SILURIAN SPECIES.

FIG.

1—13. *Meristella tumida*, Dalman. Fig. 1, a very large example from Wenlock Limestone, Dudley. Fig. 2, after original example of *Atrypa tenuistriata*, Sow. ('Sil. Syst.,' pl. xii, fig. 3.) Wenlock Limestone, Malvern Hills. Mus. Geol. Soc., London. Fig. 3, a specimen with hardly any apparent sinus or fold. Collection of Mr. E. Hollier. I am much indebted to this gentleman for the kind loan of this and other specimens. Figs. 4, 5, 8, and 9, a series of variations in shape and age, from Wenlock Limestone, Dudley, and Rushall Canal, near Walsall. Fig. 6 is from Wenlock Limestone, Malverns. Mus. Geol. Survey, London. Fig. 10, interior surface of ventral valve; Dudley. Fig. 11, interior surface of dorsal valve, but without spirals; Dudley. Fig. 12, specimen showing the spiral supports, from a very interesting example found by Mr. R. Gibbs, in the Wenlock Limestone of May Hill, and presented by him to the Mus. of Geol. Survey, London. Fig. 13, internal cast of ventral valve, showing muscular impressions in relief. In the same Museum; from the Upper Caradoc beds, Huntley Hill (?).





PLATE XII.

SILURIAN SPECIES.

10.

- 1—10. *Meristella*? *didyma*, Dalman. Fig. 1, Woolhope Limestone, Hay Head. Sharpe Collection, Mus. Geol. Soc. Fig. 2, Wenlock Limestone, Dudley. Figs. 3, 4, 6, 7, 8, W. L., Falfield, Tortworth. (Figs. 3, 4, Mus. Geol. Survey, London.) Fig. 5, Aymestry Limestone, Sedgley, near Wolverhampton. Fig. 9, internal cast enlarged. Dafaddfanchaf, near Llandeilo. Mus. Geol. Survey, London. Fig. 10, *T. canalis*, Sow., after original specimen ('Sil. Syst.,' pl. v, fig. 18); Lower Ludlow, near Uske. Mus. Geol. Soc., London.
- 11—15. *Athyris*? *depressa* (*Atrypa*), Sow. Fig. 11, original specimen, 'Sil. Syst.,' pl. xiii, fig. 6. Wenlock Shale, Stump's Wood, Malverns. Mus. Geol. Soc. Figs. 12—14, from Woolhope Limestone; road between Alfrick and Crews Hill, Malverns. Mus. Geol. Survey, London. Figs. 13 *a, b, c*, enlarged figures.
- 16—18. *Athyris*? *compressa* (*Atrypa*), Sow. Fig. 16, original specimen ('Sil. Syst.,' pl. 13, fig. 5); Woolhope Limestone; Woodside and Nash, Presteign. Mus. Geol. Soc. Fig. 16 *c, d*, enlarged. Fig. 17, Dudley. Gray's Collection, British Museum. Fig. 18, specimen alluded to by Mr. Geikie, at p. 6 of 'Memoirs of Geol. Survey of Great Britain (32 Scotland),' as from the Lower Ludlow beds, Hare Hill, Pentland Hill. Mus. Geol. Survey, London.
19. *Athyris*? *obovata* (*Atrypa*), Sow. The original specimen ('Sil. Syst.,' pl. viii, fig. 9); from Lower Ludlow beds, Mathon Edge, West flank of the Malverns. Mus. Geol. Soc. Fig. 19 *c, d*, enlarged.
20. *Meristella*? *Maclureni*, Haswell. Original specimen; Ludlow beds, Pentland Hills. Collection of Mr. Haswell. Figs. 20 *a, b*, enlarged.
- 21—25. *Retzia Salteri*, Dav. Figs. 21, 22, typical form; Wenlock Limestone; Wenlock Edge. Mus. Geol. Survey, London. Figs. 23—25 (= *R. Baylei*, Dav.); Wenlock Limestone, Benthall Edge.
- 26—30. ,, ,, var. *Bouchardii*, Dav. Different variations in shape. Fig. 26, a large transverse example; Wenlock Limestone, Benthall Edge. Collection of Dr. Holl. Fig. 27, specimen showing portions of internal spiral coils. Fig. 28, the original specimen of *R. Bouchardii*, Wenlock Limestone, Dudley. Fig. 28, enlarged figure. Fig. 29, another example, from Wenlock Limestone, Rock Farm, Longhope. Fig. 30, a very fine specimen from the same locality.

SILURIAN

PLATE 13



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